Environment Canada
Environnement Canada

Canada - Ontario Agreement on Great Lakes Water Quality

Ontario
Ministry of the Environment

Report of the Urban Drainage Subcommittee Projects Conducted 1972 - 1978

Research Report No. 101

Research Program for the Abatement of Municipal Pollution under Provisions of the Canada-Ontario Agreement on Great Lakes Water Quality

CANADA-ONTARIO AGREEMENT

RESEARCH REPORT

These RESEARCH REPORTS describe the results of investigations funded under the Research Program for the Abatement of Municipal Pollution within the provisions of the Canada-Ontario Agreement on Great Lakes Water Quality. They provide a central source of information on the studies being carried out in this program through in-house projects by both Environment Canada and the Ontario Ministry of Environment, and contracts with municipalities, research institutions and industrial organizations.

Inquiries pertaining to the Canada-Ontario Agreement RESEARCH PROGRAM should be directed to -

Wastewater Technology Centre
Canada Centre for Inland Waters
Environment Canada
P.O. Box 5050
Burlington, Ontario L7R 4A6

Ontario Ministry of Environment
Pollution Control Branch
135 St. Clair Avenue West
Toronto, Ontario M4V 1P5

REPORT OF THE URBAN DRAINAGE SUBCOMMITTEE

PROJECTS CONDUCTED 1972 - 1978

RESEARCH PROGRAM FOR THE ABATEMENT
OF MUNICIPAL POLLUTION WITHIN THE
PROVISIONS OF THE CANADA-ONTARIO
AGREEMENT ON GREAT LAKES WATER QUALITY

This document may be obtained from -

Training and Technology Transfer
Division (Water)
Environmental Protection Service
Environment Canada
Ottawa, Ontario
K1A 1C8

Ontario Ministry of the Environment
Pollution Control Branch
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

Cat. No. En 43-11/101E
ISBN 0-662-10862-0
BEAUREGARD PRESS LIMITED

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

LIST OF FIGURES

LIST OF TABLES

CANADA-ONTARIO AGREEMENT

RESEARCH PROGRAM FOR THE ABATEMENT OF MUNICIPAL POLLUTION

On August 13, 1971, the Government of Canada and the Government of the Province of Ontario signed the Canada-Ontario Agreement on Great Lakes Water Quality to ensure that the water quality of the Great Lakes is restored and protected. The purpose of this Agreement was to aid Canada and Ontario in carrying out their obligations under the Canada-United States Agreement on Great Lakes Water Quality.

Originally, the Canada-Ontario Agreement (COA) was planned to continue for five years terminating December 31, 1975, with a budget for research of $6.0 million between FY 71/72 and 75/76. The Agreement was renewed for FY 76/77 and 77/78 with a research budget of $1.0 million and for FY 78/79 and 79/80 with a budget of $130,000. The Agreement has been renegotiated for FY 80/81 and beyond to cover the whole of the Great Lakes system with an extended time frame. Both surveillance and research are identified in the new Agreement.

A considerable amount of research was conducted in-house by the Ontario Ministry of the Environment (MOE) and by Environment Canada, but external contract studies were also a significant part of the total program. Research was carried out under contract by a number of industrial organizations, consulting engineering firms, research foundations and universities.

The broad areas of research activity under the Canada-Ontario Agreement were as follows:

1) chemical treatment using various existing municipal processes,
2) removal of phosphorus from sewage at municipal sewage treatment plants,
3) chemical-physical and other advanced wastewater treatment concepts,
4) the treatment, handling and ultimate disposal of sewage sludge,
5) the upgrading of existing municipal sewage treatment plants,

6) studies on the reduction of discharges of persistent organic contaminants and toxic substances from municipal treatment plants, and

7) the abatement of pollution from storm and combined sewers and urban drainage.

Four subcommittees were appointed to administer programs in these activity areas. The report which follows is an account of the work of one of these subcommittees (Urban Drainage Subcommittee) between 1972 and 1978, covering the research activity described in item 7 above.

URBAN DRAINAGE SUBCOMMITTEE

The Urban Drainage Subcommittee was established under the Canada-Ontario Agreement on Great Lakes Quality, as part of the research program for the abatement of municipal pollution. Identified as the "Storm and Combined Sewers Subcommittee" between 1972 and February 1975, it was created in response to concern about pollution caused by urban surface runoff and overflows from combined sewerage systems. The subcommittee was concerned with approaches to the definition and resolution of the problem of pollution from storm and combined sewers, and in activities related chiefly to the handling and ultimate disposal of storm water from urban areas.

Initial activity was concerned with the development of a research strategy which was generally as set out below. The subcommittee also was charged with the responsibility of overseeing all projects in this area, as well as responding to questions posed by various members of the Agreement. This subcommittee received funds from both the Canada-U.S. Agreement and the Canada-Ontario Agreement for its research projects as described in the project summaries.

Terms of Reference of the Subcommittee

The subcommittee's terms of reference were:

1) to define the magnitude of the pollution due to storm water in the Great Lakes basin,
2) to establish priorities and schedules for studies directed toward potential solutions to storm water pollution problems, and
3) to develop a strategy for implementing solutions.

Urban Drainage Problems

The significance of urban surface runoff and overflows from combined sewerage systems as pollution sources is indicated in Table 1, which shows that the composition of combined sewage is comparable to that of raw or primary treated sanitary sewage, and Table 2, which shows that surface runoff may be a significant source of BOD, solids, nutrients, and bacteria. The Subcommittee recognizes, however, that these problems

TABLE 1. COMPOSITION OF COMBINED SEWAGE IN COMPARISON WITH RAW AND TREATED SANITARY SEWAGE*

		5-day BOD_5 mg/L	Suspended Solids mg/L	Total Nitrogen mg/L	Total Phosphorous mg/L
Combined Sewage					
	Average	140	500	11	6
	Range	1.5 - 685	4 - 8800	3 - 24	1 - 11.6
Typical Raw Sanitary Sewage					
	Average	200	200	40	10
	Range	100 - 300	100 - 350		
Typical Treated Sewage					
Primary	Average	135	80	35	7.5
	Range	70 - 200	40 - 120		
Secondary	Average	25	15	30	5.0
	Range	15 - 45	10 - 30		

*Number of municipalities surveyed - 15

TABLE 2. COMPOSITION OF URBAN SURFACE RUNOFF

	BOD_5 mg/L	Suspended Solids mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L	Fecal*** Coliform MPN/100 mL	Total*** Coliform MPN/100 mL
East York:						
Barrington Outfall*						
COA Project 74-1-40						
Average	75	120	5.7	0.9		
Range	2.5-320	15-490	0.02-20	0.1-3.8	10 000-340 000	25 000-5 000 000
North York:						
Brucewood Outfall**						
COA Project 73-3-12+						
Average	12	600	4.0	0.4		
Range	2.3-53	49-1023	0.5-11.5	0.09-0.65	520-2400	2100-7000

* 12-14 storms analysed (February 1974 - November 1975).
** 15 storms analysed (April - December 1974).
***Range for coliforms refers to range of average values for storm events.

cannot be completely isolated from other urban drainage problems, which are summarized in Table 3. All of these problems were considered during formulation of the Urban Drainage Program and the Proposed Model Policies for Urban Drainage Management.

Research Strategy

Combined-sewer overflows have long been recognized as major contributors to the pollution of our watercourses. There is also emerging evidence that storm water discharges from totally separate sewer systems are of such quality that impairment of waters receiving these discharges may result. Problems related to these overflows and discharges will soon be faced by most municipalities in the Great Lakes basin, and programs will have to be implemented for their control. There are a variety of abatement measures available but none can be singled out as being applicable in every situation. A detailed analysis of each sewer network and an abatement scheme developed to suit particular conditions will be required.

An efficient and economical way to analyze and assess individual urban sewer systems is through simulation of conditions by mathematical modelling. Such modelling techniques use existing data on rainfall, dry-weather sewage flows, and physical characteristics of both the catchment area and sewer system to predict the frequency, quality and quantity of overflows and discharges and their effects on receiving waters. Cost-benefit or cost-effective analyses for the various methods of control or elimination are possible and can be used in the development of comprehensive pollution abatement programs for individual municipalities.

Several proprietary and non-proprietary models have been developed in North America and Europe. However, it appears that none are wholly suitable for application in Canada without modifications which reflect Canadian climate, construction and engineering costs, engineering practices, and environmental concerns.

The first phase of the Urban Drainage Subcommittee's program was the development of a "Canadian Storm Water Management Model". This model was tested under field conditions and found suitable. It has been made

TABLE 3. URBAN DRAINAGE PROBLEMS

Problem	Causes	Effects
DEVELOPED AREAS		
Overloaded Sewerage Systems	- infiltration - redevelopment to higher density land uses - development of upstream lands	- local flooding - pollution of receiving waters by wet and dry weather by-passing of sanitary sewage - increased cost of treating sewage
Combined Sewer Overflows	- conventional interceptors and treatment plants handle only 3 to 5 times dry weather flow	- pollution of receiving waters by wet weather overflows of mixed sewage and surface runoff
Urban Surface Runoff Pollution	- build-up of pollutants on impervious areas from all urban activities	- pollution of receiving waters by surface runoff
DEVELOPING AREAS		
Increased Volume and Rate of Surface Runoff	- removal of protective surface vegetation and paving - drainage systems installed to deal with local flooding - construction in flood plains, and filling of ponds and swamps	- local flooding - erosion, and siltation of receiving waters - downstream flooding, channel erosion, and siltation of receiving waters - loss of natural storage areas, and of recreational and aesthetic amenities
Construction Activities	- heavy machinery disturbs stream banks - topsoil removal - grading and excavation	- sedimentation in streams and lakes - increased turbidity in streams and lakes

available to municipalities for analysis of their individual sewage systems. During the preparation of the model, studies were also conducted to obtain additional and updated data on runoff water quality and quantity, snowmelt quality, and information on new control and treatment devices and their associated costs.

Urban Drainage Program

The terms of reference of the Urban Drainage Subcommittee provided the basis for the following three goals of the Urban Drainage Program:

1) to define the problem,
2) to develop solution capability,
3) to develop a strategy for implementing solutions.

Figure 1 illustrates the organization and timing of the Urban Drainage Program. The projects are listed, together with their costs, in Table 4; the sources and magnitude of funding are shown in Table 5. The background and justification for topics included in the program are discussed below. Individual projects are described in the final section of this report.

Problem Definition

Although combined sewage and surface runoff are recognized as potential sources of pollution (Tables 1 and 2), their significance relative to other pollution sources and the cost of implementing pollution controls in the Great Lakes basin have not been extensively explored. A project (74-8-21) carried out by the American Public Works Association provided an estimate of pollution loadings from combined sewage and surface runoff loads and an indication of control costs.

Sanitary sewerage systems include by-passes to prevent local floodings when system capacity is exceeded. When a by-pass functions, untreated sanitary sewage is discharged from the system. An assessment of the frequency and magnitude of municipal by-pass flow is a continuing study by the Ontario Ministry of the Environment.

Although information about composition of combined sewage and surface runoff is available, little of this type of information has been obtained for the Great Lakes basin. Results from a number of Urban

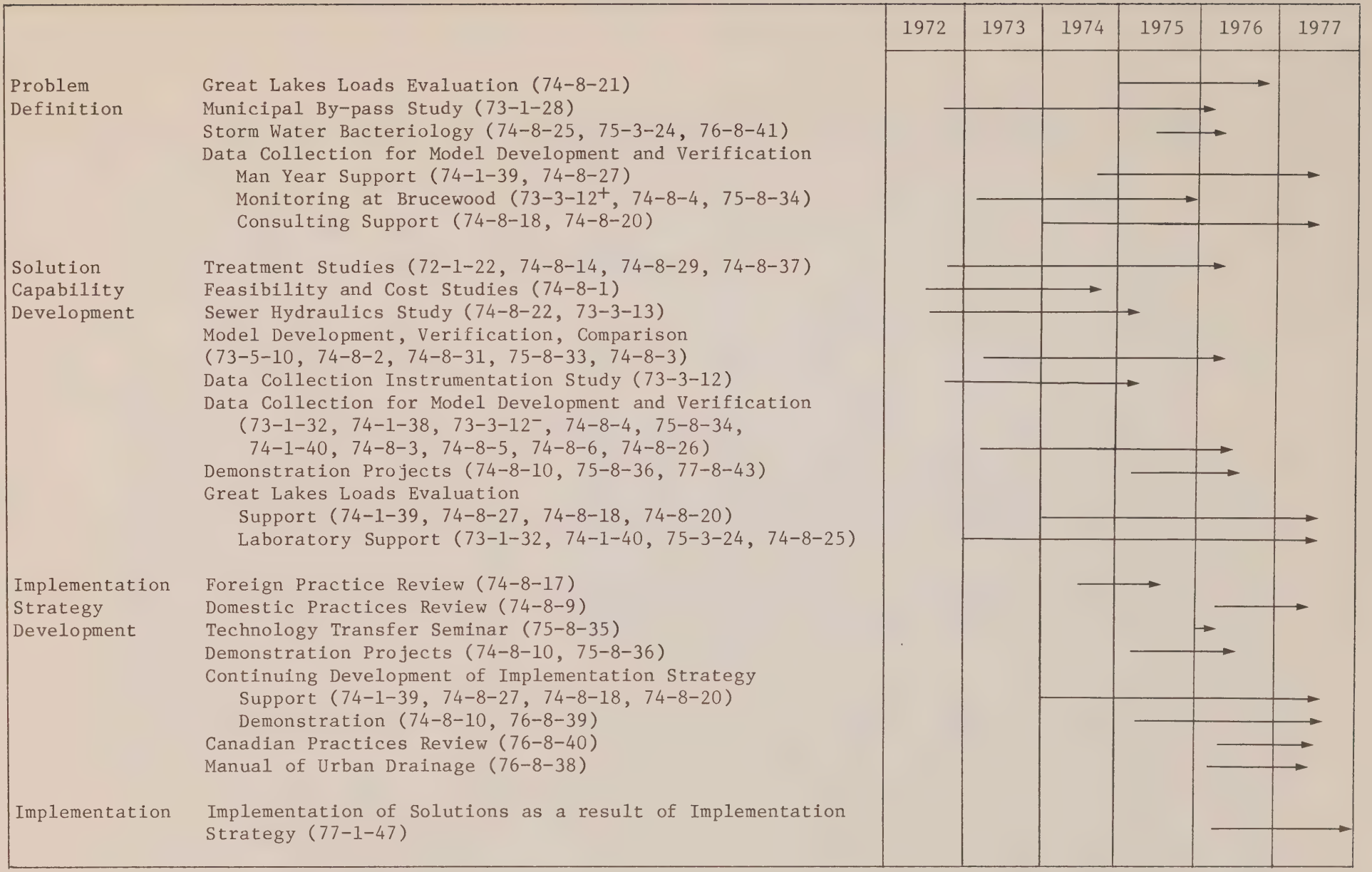

FIGURE 1. URBAN DRAINAGE PROGRAM ACTIVITY CHART

TABLE 4. LIST OF PROJECTS, CONTRACTORS, FUNDING AND REPORTS

Project Number	Contractor	Project Leader or SLO	Abbreviated Description or Project	Total Expenses $ K	COA Report No.
72-1-22	Ministry of Environment	F.A. Tonelli	Screens Study	113.5	
73-1-28	Ministry of Environment	F.A. Tonelli	Sewage By-Pass Studies	101.2	
73-1-32	Ministry of Environment	D. Weatherbe	Sample Analysis for 73-3-12+	16.2	97
74-1-38	Ministry of Environment	D. Weatherbe	Sample Analysis for 74-8-5	4.4	
74-1-39	Ministry of Environment	D. Weatherbe	Man-year and Expenses	53.6	
74-1-40	Ministry of Environment	D. Weatherbe	Sample Analysis for 74-8-5	24.3	66
77-1-47	M.M. Dillon Ltd.	P. Seto	U.D. Policy Compilation	10.9	
73-3-12-	EMS, Environment Canada	J. Marsalek	Burlington Sewer Studies	72.1	57,95
73-3-12	EMS, Environment Canada	J. Marsalek	Instrumentation for Field Studies	30.0	42
73-3-12+	J.F. MacLaren Ltd.	J. Marsalek	Brucewood Data Collection and Modelling	17.1	
73-3-13	EMS, Environment Canada	J. Marsalek	Sewer Junction Study 74-8-22	9.9	
75-3-24	EMS, Environment Canada	J. Marsalek	Monitoring at North York and Burlington	6.4	87
73-5-10	Proctor and Redfern Ltd./ J.F. MacLaren Ltd.	J. Marsalek	SWMM Contract (COA and EPS Funding)	203.2	47,48,62
74-8-1	U of Toronto	D. Hay	Separate vs Combined Sewer Cost	6.6	34
74-8-2	N.S. Technical College	D. Hay	Halifax Runoff and Modelling	3.6	43
74-8-3	N.S. Technical College	D. Hay	Halifax Catchment Data Collection	7.7	41
74-8-4	J.F. MacLaren Ltd.	J. Marsalek	See 73-3-12+; moved to 75-8-34	12.0	
74-8-5	M.M. Dillon Ltd.	D. Weatherbe	Toronto Area Data Collection	85.2	97
74-8-6	Gore & Storrie Ltd.	J. Marsalek	Hamilton Area Data Collection	77.0	99
74-8-9	Ministry of Environment	F.A. Tonelli	Review of Problems in Combined Sewer Systems	19.6	93
74-8-10	Gore & Storrie Ltd.	D. Hay	Design Demonstration of SWMM at Merivale	17.5	89
74-8-14	Ministry of Environment	F.A. Tonelli	Physical Treatment Systems (See 76-8-37)	0.6	
74-8-17	Albery, Pullerits, Dickson and Assoc. Ltd.	D. Hay	Foreign Practices Regulatory Review	36.3	45
74-8-18	C.D. Howard	T.S. Munro	Advisory Services from Unies Ltd.	43.0	
74-8-20	D.H. Waller	T.S. Munro	Advisory Services from D. Waller	53.3	
74-8-21	American Public Works Association	T. Koplyay	Survey of Urban Pollution in Great Lakes	55.4	81
74-8-22	EMS, Environment Canada	J. Marsalek	Sewer Connection Study (73-3-13)	12.5	
74-8-25	Ministry of Environment	D. Weatherbe	Monitoring at East York and Guelph	9.8	87
74-8-26	EMS, Environment Canada	J. Marsalek	Laboratory Work at CCIW to support 74-8-6	42.2	
74-8-27	EPS, Environment Canada	T. Koplyay	Man-year Contribution and Expenses	102.0	
74-8-29	Pollutech Pollution Advisory Services Ltd.	A. Netzer	Microscreens and Ozonation Investigations	15.9	36
74-8-31	J.F. MacLaren Ltd.	J. Marsalek	Review of Canadian Design Practices	50.0	26
75-8-33	Ministry of Environment	D. Weatherbe	Storm Water Modelling	22.4	94
75-8-34	J.F. MacLaren Ltd.	J. Marsalek	See 73-3-12+ and 74-8-4 (Brucewood)	10.9	
75-8-35	Proctor and Redfern Ltd./ J.F. MacLaren Ltd.		SWMM Technology Transfer Conference No. 4	18.0	
75-8-36	U of Toronto	D. Weatherbe	Meadowvale West Lake Mississauga	4.7	63
76-8-37	Ministry of Environment	F.A. Tonelli	Physical-Chemical Treatment (74-8-14)	27.8	
76-8-38	Environment Canada/ Ministry of Environment	D. Weatherbe	Manual of Urban Drainage	8.6	
76-8-39	J.F. MacLaren Ltd.	CMHC	St. Thomas Demonstration	nil	
76-8-40	Gore & Storrie Ltd.	D. Hay	Canadian Municipal Practices Review	8.0	82
76-8-41	EMS, Environment Canada	B. Dutka	Investigation of Pathogens	12.4	87
77-8-43	J.F. MacLaren Ltd.	J. Marsalek	Integration of Reports on 73-3-12+, 75-8-34 and 74-8-4	1.0	100
			TOTAL:	1426.8	

TABLE 5. TOTAL PROJECT EXPENSES RELATIVE TO FUNDING SOURCE

	Environment Canada, Environmental Management Service	Environment Canada, Environmental Protection Service	Canada-Ontario Agreement Paid half by Canada and half by Ontario	Totals $ K
FY 73/74	65.9	17.2	174.5	257.6
FY 74/75	38.8	290.3	121.2	450.3
FY 75/76	53.3	169.3	91.4	314.0
FY 76/77	nil	143.4	95.9	239.3
FY 77/78	nil	41.0	124.6	165.6
TOTAL:	158.0	661.2	607.6	1426.8

Drainage Program projects have provided data for computer model calibration and verification and also have helped to characterize combined sewage and surface runoff from some specific Ontario communities. Information on levels of bacterial indicators and pathogens in surface runoff samples from four of these studies has assisted in assessing health hazards associated with urban surface runoff.

Solution Capability Development

The Urban Drainage Subcommittee has examined management strategies and technologies that might be applied to the solution of urban drainage problems. Areas where additional knowledge is required have been identified, and projects that have developed technology and capabilities needed to solve urban drainage problems in Canada have been supported.

A number of research projects have investigated processes for treatment of sanitary sewage by-pass flows, storm water, and combined sewer overflow. Several feasibility and cost studies have considered regulation of combined sewage flows. The relative costs of treating effluents from combined separate gravity and pressure sewerage systems have been compared. A study of hydraulic losses at sewer pipe connections and junctions has contributed to the design of more economic sewerage systems.

Computer models for simulations of water quantity and quality in urban drainage systems provide an improved capability for planning and design of urban drainage systems. Two projects of the subcommittee have compared the performance of available quantity models with flow measurements from Canadian urban watersheds. The largest single project (73-5-10) supported under the Urban Drainage Program was based on improvement and verification of the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) for Canadian conditions.

Given basic input such as rainfall from a single storm event, demographic and sewerage system data, the model simulates variations in quantity and composition of storm runoff, routes and flows through the system of sewers, and control and treatment devices, and produces estimates of treatment and storage costs and pollution loads in receiving waters. Important aspects of this project have been the selection and modification of a model that can simulate long-term sewerage system behavior, such as frequencies and volumes of overflows, and the development of a data analysis program that prepares input data using existing meteorological data banks for both the single event and the frequency model. The study of Great Lakes pollution loads, which employed the frequency simulation model STORM, also contributed to the development and transfer of methodology for loadings and cost analysis.

The Urban Drainage Program includes field data collection projects that have yielded quantity and quality information from Canadian watersheds to be used for verification and continuing development of urban drainage models. These projects have aided problem definition. A study of instrumentation for field data collection has assisted the subcommittee in its development of criteria for design of field installations. Some of the results from the field installations were used in the SWMM study. Results from two combined sewer monitoring projects have been applied by the contractors to verify model predictions for the respective field measurement drainage basins. Two demonstration projects supported by the Urban Drainage Program provided field evaluations of the application of simulation models and of pollution control techniques for storm water.

Implementation Strategy Development

Having identified major urban drainage problems and available means for their solution, the Urban Drainage Subcommittee was charged with developing a strategy to implement solutions. Solutions may come about as a result of legislation (including fiscal policies) and regulation, increased awareness of the problems and the availability of solutions on the part of municipal officials, and improved capability on the part of consulting engineers in the application of simulation models for system design and evaluation.

Two projects are intended to provide information about legislative and regulatory practices related to urban drainage problems in Europe, the United States, and Canada. The most effective of these practices were incorporated into proposals for implementation in Canada.

Two technology transfer workshops were held in 1976 to make information about the value and implementation of urban drainage models from the SWMM project available to municipal officials and consultants. See Appendix 1: COA Conference Proceedings No. 4.

The demonstration projects referred to previously helped to illustrate and publicize examples of methodology and technology that can be applied to the solution of urban drainage problems.

Most of the subcommittee's attention in 1977 was devoted to the assessment of results, the development of a policy on urban drainage to be recommended to the Governments of Ontario and Canada, and the compilation of a strategy to implement this policy. Included were a project to develop a manual on urban drainage practice and a systems demonstration project in a municipality with urban drainage problems. The subcommittee sponsored a seminar in March 1977 to present an overview of the urban drainage problem, techniques of analysis (models), and potential solutions. See Appendix 2: COA Conference Proceedings No. 5.

Proposed Model Policies

These policies have the multiple objectives of: 1) downstream flood control; 2) pollution control; 3) channel protection; as well as 4) the original objective of protection of property by adequate urban drainage. These would be achieved by requiring planning and design of

controls on the rate of runoff from development sites (see project 77-1-47 and Appendix 3), through the successful combination of a variety of techniques such as: erosion control during construction, flow retardation/retention ponds, inlet control devices, treatment of runoff where stream uses dictate a need, and adoption of the concept of "major-minor" drainage systems.

In developing the Proposed Model Policies, the subcommittee asked municipalities to review the problems associated with existing drainage systems by carrying out activities such as: estimating the quality, quantity, and frequency of discharges from storm and combined sewers; estimating the cost of control measures; and outlining an acceptable abatement program.

Staff and Consulting Service

Table 6 contains the names and affiliations of people who have served on the Urban Drainage Subcommittee and its associate groups between 1973 and 1978.

Administrative and technical support to the Urban Drainage Subcommittee was provided by staff of the Ontario Ministry of the Environment and Environmental Protection Service, Environment Canada. Professional expertise related to development and evaluation of the Urban Drainage Program and projects was provided by a four-man technical advisory group (TAG) consisting of Charles D.D. Howard, Donald H. Waller, Harry C. Torno, and Richard S. Field. The services of Mr. Field and Mr. Torno were provided through the courtesy of the United States Environmental Protection Agency.

Project Descriptions and Summaries

The following summaries present brief descriptions of projects supported by the Urban Drainage Program. As indicated in the summaries, the program was supported by the Canadian and Ontario governments under several funding and administrative arrangements; actual yearly costs for each project are shown. The relationships of individual projects to the overall program are indicated in Figure 1. Table 4 lists the COA reports that have been published for respective projects.

TABLE 6. URBAN DRAINAGE SUBCOMMITTEE AND ITS ASSOCIATE GROUPS

Urban Drainage Subcommittee

G.H. Mills (Co-chairman)	- Ontario Ministry of the Environment
R.W. Slater (Co-Chairman)	- Environment Canada
G.V. Buxton	- Environment Canada
C.P. Fisher	- Environment Canada
P.D. Foley	- Ontario Ministry of the Environment
A.J. Harris	- Ontario Ministry of the Environment
D.J. Hay	- Environment Canada
T.M. Koplyay	- Environment Canada
J. Marsalek	- Environment Canada
R.E. Mills	- Environment Canada
Z.D. Novak	- Ontario Ministry of the Environment
L.D. Roberts	- Canada Mortgage and Housing Corporation
P. Seto (Alternate)	- Ontario Ministry of the Environment
J.F.H. Shimwell	- Canada Mortgage and Housing Corporation
F.A. Tonelli	- Ontario Ministry of the Environment
G.L. Van Fleet	- Ontario Ministry of the Environment
D.B. Walter	- Environment Canada
D.G. Weatherbe	- Ontario Ministry of the Environment

Working Group Appointed for the Urban Drainage Subcommittee

L. Anthony (Observer)	- Supply and Services Canada
D.J. Hay	- Environment Canada
J.R. Holinsky (Observer)	- Supply and Services Canada
T.M. Koplyay	- Environment Canada
J. Marsalek	- Environment Canada
S.A. Moin	- Ontario Ministry of the Environment
F.A. Tonelli	- Ontario Ministry of the Environment
D.G. Weatherbe	- Ontario Ministry of the Environment

Technical Advisory Group Retained for the Urban Drainage Subcommittee

R. Field	- U.S. Environmental Protection Agency
C.D. Howard	- Charles Howard and Associates Limited
H.C. Torno	- U.S. Environmental Protection Agency
D.H. Waller	- Nova Scotia Technical College

In addition to the projects outlined below, the subcommittee maintained liaison with projects having a direct or indirect relation to the UDS program. These include:

1) the urban runoff control program of the U.S. EPA;
2) the International Reference Group on Great Lakes Pollution from Land Use Activities (International Joint Commission);
3) MOE 'in-house' projects, such as a study of urban runoff in Guelph as part of the Grand River Study;
4) Canada Mortgage and Housing Corporation funded projects in the area of sewage collection and treatment, such as studies of water quality in retention ponds in Winnipeg, St. Thomas, and Nepean (Ottawa-Carleton); and
5) Metro Toronto SWIRL Concentrator.

PROJECT SUMMARY

Project Title	:	Full-Scale Evaluation of High Rate Screening Devices for Treatment of Sanitary Sewage By-Pass Flow
Project Leader	:	F.A. Tonelli
Program Category	:	Solution Capability Development
Project Number	:	72-1-22
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
73/74	73.9
74/75	29.8
75/76	9.8
Total	113.5

Contractor	:	Ministry of the Environment
Contract Time	:	November 1972 - March 1976
Status of Reports	:	The final report is in preparation in 1979. Interim reports are available.

Description and Summary

The primary objective of the research was to establish the operational feasibility of treating sanitary sewage by-pass flow with fine mesh screen units and to determine the degree of treatment obtained with the units. Another objective was to determine the applicability of the units as tertiary treatment devices.

The research evaluates fine mesh screening units installed and operated at the Belleville water pollution control plant (WPCP), which has significant infiltration problems. The treatment capability of each unit was evaluated.

Summary of Report on Project 72-1-22

Project 72-1-22: FULL-SCALE EVALUATION OF HIGH RATE SCREENING DEVICES FOR THE TREATMENT OF SANITARY BY-PASS FLOW - H. Kronis and F.A. Tonelli, Ontario Ministry of the Environment

Four fine mesh, high rate screening devices were evaluated on combined sewage under wet and dry weather conditions. The study was carried out during 1974-75 at the Belleville, Ontario WPCP where influent sewage is subject to substantial infiltration, dilution and flow peaking during wet weather. The commercially-sized screen units consisted of a 1.5-m (60-inch) diameter centrifugal wastewater concentrator (CWC) with 105-micrometer screen apertures; two stationary inclined screens, one 0.6-m (24-inch) wide DSM screen and one 1.8-m (72-inch) wide Hydrasieve, having 305 and 762 micrometer apertures, respectively; and a 1.5-m (60-inch) long rotating horizontal drum screen (Rotostrainer) with 500-micrometer apertures.

The object of the study was to determine the feasibility, treatment efficiency, equipment reliability, and cost of screening using the four devices.

It was concluded that screening had the potential of reducing pollutants in combined sewer overflows. Both the hydraulic capacity and the degree of pollutant removal are dependent largely on the type of screening device, the screen aperture, and the availability of an effective backwash system. The hydraulic capacity of the four units ranged from 0.78 to 2.4 $m^3/m^2 \cdot min$ (16 to 50 $gal/min\text{-}ft^2$).

Typical mean percentage removals based on concentration changes under first flush conditions were as follows:

	SS mg/L		BOD mg/L		Settleable Solids mg/L	
	Mean	Range	Mean	Range	Mean	Range
CWC	32	16-49	24	12-34	79	67-95
DSM Screen	19	7-23	18	8-13	58	42-64
Hydrasieve	9	3-21	5	0-12	23	3-48
Rotostrainer	5	-	10	-	23	-

In dry weather or storm events without a first flush, pollutant reductions were generally substantially less.

For CWC operation, screen efficiency was also estimated on the basis of overall pollutant mass transfer to the concentrate and included flow splitting and the actual 'enrichment' or concentration effect. For first-flush storm conditions, suspended solids mass transfer was approximately 32% from flow splitting and 20% from enrichment for a total of 52%.

All four units had the potential for automated operation. The life of the CWC screen panels was estimated to be up to 500 hours. No deterioration of the media of the DSM screen, Hydrasieve, or Rotostrainer was observed during the study.

1976 capital and operating costs were estimated as follows:

Device	Installed Capacity m^3/d	Units	Capital Cost $/1000 m^3	Operating Cost ¢/m^3 100-8000 Op. h/yr
CWC	27 252	4	5654	5.0 to 1.3
DSM Screen	28 388	10	5773	3.2 to 0.2
Rotostrainer	34 065	3	4465	2.4 to 1.6
Hydrasieve	No costing was developed.			

PROJECT SUMMARY

Project Title	:	Assessment of Municipal Sanitary Sewer By-Pass Flows
Project Leader	:	F.A. Tonelli
Program Category	:	Problem Definition
Project Number	:	73-1-28
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
73/74	43.5
74/75	36.3
75/76	21.4
Total	101.2

Contractor	:	Ministry of the Environment
Contract Time	:	November 1972 - January 1976
Status of Reports	:	Final report is in preparation in 1979. Interim reports are available.

Description and Summary

The objective of the research was to collect data on quantity, quality, and frequency of municipal sewage by-pass flows in four municipalities. The data collection for this study was done by installing flow-measuring devices and automatic sampling equipment in municipal sewerage system by-pass locations including water pollution control plant (WPCP) by-pass. In order to place by-pass information in context, precipitation data and information on secondary effluent quantity and quality from WPCP's were also collected.

PROJECT SUMMARY

Project Title	:	Analysis and Investigation of Storm and Combined Sewers in North York
Scientific Liaison Officer:		D.G. Weatherbe
Program Category	:	Solution Capability Development and Data Collection
Project Number	:	73-1-32
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
73/74	3.7
75/76	11.5
76/77	0.5
77/78	0.5
Total	16.2

Contractor	:	Ministry of the Environment, Laboratory Services Branch
Contract Time	:	April 1973 - March 1976
Status of Reports	:	No report issued on this project. Analytical information generated has been used in various other reports.

Description and Summary

This project supplied analytical data and sample analysis for the North York Data Collection Exercise (Brucewood) and for projects 73-3-12+, 74-8-4, and 75-8-34 (J.F. MacLaren Ltd. contracts).

PROJECT SUMMARY

Project Title	:	Laboratory Analysis of Toronto Area Samples for Data Collection for EPA Storm Water Management Model Verification
Scientific Liaison Officer	:	D.G. Weatherbe
Program Category	:	Solution Capability Development
Project Number	:	74-1-38
Funding Source	:	100% Canada-Ontario Agreement
Funding	:	FY 74/75 = $4.4 K
Contractor	:	Ministry of the Environment, Laboratory Services Branch
Contract Time	:	April 1975 - March 1976
Status of Reports	:	No report was issued on this project. Analytical information has been used in various other reports.

Description and Summary

This project supplied analytical data and sample analysis for Project 74-8-5 (M.M. Dillon Ltd. contract).

PROJECT SUMMARY

Project Title	:	Technical support supplied to the Urban Drainage Subcommittee with respect to Project Administration and Program Analysis
Scientific Liaison Officer:		G.H. Mills
Program Category	:	Problem definition, solution capability development, implementation strategy development.
Project Number	:	74-1-39
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
74/75	4.7
75/76	9.0
76/77	19.2
77/78	20.7
Total	53.6

Contractor	:	Ministry of the Environment, Water Resources Branch
Contract Time	:	April 1974 - March 1978
Status of Reports	:	No report was issued on this project. The project supplied "man-year assistance" to various other projects and to the Urban Drainage Subcommittee.

Description and Summary

The "man-year assistance" provided technical support to the subcommittee for project administration and program analysis. Responsibilities included the review of project status both from technical and financial viewpoints, the preparation of project work statements, and all in-house assignments related to data collection, program coordination and EDP modelling.

PROJECT SUMMARY

Project Title	:	Water Quality of Urban Storm Water Runoff in the Borough of East York
Project Leader	:	W. Gordon Mills
Scientific Liaison Officer	:	D.G. Weatherbe
Program Category	:	Solution Capability Development
Project Number	:	74-1-40
Funding Source	:	100% Canada-Ontario Agreement
Funding	:	FY 76/77: $ K 14.9 FY 77/78: $ K 9.4 Total: $ K 24.3
Contractor	:	Borough of East York
Contract Time	:	April 1975 - March 1978
Status of Reports	:	Report published as COA Research Report No. 66.

Description and Summary

The project provided laboratory analysis for a storm water outfall sampling program in the borough of East York under the supervision of Mr. W. Gordon Mills, Director of Engineering for the borough. Two storm sewer outfalls draining urban areas were monitored by a combination of manual and automatic sampling and automatic flow recorders.

The objective of the program was to characterize the quality of storm water draining from the urban area and to assess the pollution potential of the drainage. The findings were reported in a Master's thesis for the University of Toronto and include hydrographs, pollutographs, rainfall distribution data, and a description of the urban area.

Bacteriological monitoring for Project 74-8-25 took place at one location. Project 73-3-12 formerly covered some work later assigned to Project 74-1-40. Project 74-1-40 continued through to March 1978 as a laboratory support effort to several projects and supported Project 74-8-5 in FY 76/77 as required.

Summary of Research Report No. 66

Project 74-1-40: WATER QUALITY OF URBAN STORMWATER RUNOFF IN THE BOROUGH OF EAST YORK - W. Gordon Mills, Borough of East York, Ontario

Combined-sewer overflows have been in existence for many years, but they were not recognized as a significant problem when sewer systems were constructed. When attention was focused on them, they were found to be significant contributors to water pollution because of the high content of untreated sanitary sewage which they contained. With the recognition of the problem caused by overflows came proposals for their elimination.

Two study areas were established in the Borough of East York. One area, Broadview, was abandoned after a short time because of instrumentation problems; the other area, Barrington, was monitored for a period of almost three years. The report gives water quality results for 18 events at Barrington and three at Broadview. Parameters recorded throughout the study included suspended solids, BOD, lead, phenolic compounds, chlorides, COD, total and dissolved phosphorus, ammonia, Kjeldahl nitrogen, nitrate, nitrite, and conductivity. Parameters recorded occasionally included pH, TOC, sodium, potassium, iron, alkalinity, hardness, dissolved and total solids, heavy metals, petroleum hydrocarbons, sulphates and herbicides.

Barrington is an old residential area with combined sewers constructed in the 1920's and a separate storm sewer system built in the late 1960's. All tests were run on separated storm water from the new storm sewer system. The drainage area was 22.4 hectares, of which 17.4 hectares contributed runoff to the sewer system; roof drainage was connected to the older combined sewer system.

Results are provided in tabular form and include: the peak concentrations of all parameters in all events monitored, peak mass loadings for all events (mass loading being the rate at which the parameter is being carried by the runoff), the mass of material carried by runoff in each event, and the flow-weighted mean concentration for each event. Results are also provided in graphical form. Each graph shows the rainfall and concentration and mass loading for each parameter in each

event. Only eight graphs are included in the report. These eight graphs present data for the storm of September 11, 1975. All the remaining graphs are available on request.

The author recommends the upgrading of municipal housecleaning programs, treatment at pollution control plants for low flows in separated storm sewers and for the first hour's runoff from a rainstorm, and revision of legislation governing runoff quality.

PROJECT SUMMARY

Project Title	:	Proposed Model Policies for Urban Drainage Management
Project Leader	:	P. Seto and D.G. Weatherbe and Urban Drainage Policy Committee
Program Category	:	Implementation Strategy Development
Project Number	:	77-1-47
Funding Source	:	100% Canada-Ontario Agreement
Funding	:	FY 77/78 = $10.9 K
Contractor:		Ministry of the Environment in cooperation with other Ontario Ministries and Policy Committee members and M.M. Dillon Ltd.
Contract Time	:	April 1977 to March 1978
Status of Reports	:	Report will be published in 1980.

Description and Summary

The report will present the Urban Drainage Policy Subcommittee's recommendations for model policies for urban drainage management. A synopsis appears in Appendix 3.

PROJECT SUMMARY

Project Title	:	Burlington Sewer Studies Data Collection
Scientific Liaison Officer:		J. Marsalek
Program Category	:	Solution Capability Development
Project Number	:	73-3-12
Funding Source	:	39% Canada-Ontario Agreement 38% Environment Canada (EMS) 23% Environment Canada (EPS)

Funding :

FY	$ K	
73/74	13.5	(COA)
74/75	10.3	(EMS)
75/76	17.0	(EMS)
76/77	16.3	(EPS)
77/78	15.0	(COA)
Total	72.1	

Contractor	:	Environment Canada, Environmental Management Service
Contract Time	:	April 1974 - March 1976
Status of Reports	:	Volume I of this investigation was published under the title of "Malvern Urban Test Catchment", COA Research Report No. 57. Volume II published as Research Report No. 95.

Description and Summary :

The object of this study was to monitor precipitation and runoff in two urban watersheds. After the experimental data were analyzed runoff simulations with the 1975 version of SWMM were made. Two urban test areas were established in the City of Burlington. One was a residential area of 23 hectares (57 acres), with fully detached single-family units and a housing density of five units per acre.

The second area was a commercial plaza of 6.9 hectares (17 acres), occupied by three large chain stores, a number of small stores, two gasoline stations, and a service garage. During 1975, runoff quantity and quality were monitored in the residential area for a large number of storm events.

Summary of Research Report No. 57

Project 73-3-12: MALVERN URBAN TEST CATCHMENT, VOLUME I - J. Marsalek
Environmental Management Service, Environment Canada

The increasing urbanization of Canadian society has made a dramatic impact on the hydrological cycle in the affected areas. A large proportion of an urbanized area is impervious to water and this has contributed to the acceleration and increase of surface runoff, which is typically conveyed by sewers. The runoff water, which is to some degree polluted, is usually discharged into local receiving waters without treatment. The uncontrolled discharge from combined and separate sewers is recognized as one of the major contributions to the lowering of water quality in rivers and lakes. An urgent need for urban runoff data has been identified by the Urban Drainage Subcommittee and several data collection projects have been initiated. One of these projects, the monitoring and simulation of urban runoff on the Malvern test catchment in Burlington, is described in this report.

The Malvern test catchment is located in a residential area served by separate storm sewers. The catchment was established and has been monitored by the Hydraulics Research Division of the Canada Centre for Inland Waters in Burlington, Ontario.

The terms of reference of the project were:

1) to establish an urban test catchment served by storm sewers,
2) to design, install and operate a data acquisition system monitoring precipitation and runoff quality,
3) to simulate selected storm events using the Storm Water Management Model (Runoff Block only).

This report deals mainly with the description of the test catchment and of the instrumentation. Only a limited number of storms were recorded during the initial stage of the project (1973); these observations are included.

The Malvern test catchment, which represents a typical modern residential area, is well-suited for urban runoff studies. The catchment is well-defined and its basic physical characteristics (area, imperviousness, slope) have been fairly accurately determined.

The runoff volume, peak rate, and time to peak were simulated reasonably well by a partially calibrated Runoff block. The representation of the catchment by ten subcatchments and 21 sewer pipes allowed a description of the catchment and of its response. The SWMM default values were found suitable for the Malvern catchment with two possible exceptions. The simulated runoff volumes were underestimated by three percent on average; about two-thirds of all the simulated volumes were within six percent of the observed ones. The simulated runoff peak flows were underestimated by ten percent; about two-thirds of all the simulated flows were within 15 percent of the observed ones.

The simulated times to peak were on average about equal to the observed ones. Two-thirds of all the simulated times to peak were within five percent of the observed ones.

The accuracies of the SWMM simulations obtained are better than those previously reported and are likely to follow from the good quality of the Malvern field data used in the SWMM testing. The Runoff block of the SWMM appears to simulate accurately runoff events on the Malvern catchment for storms of high frequency of occurrence.

The author recommends continued monitoring of urban runoff at the Malvern urban test catchment and that it be expanded to include monitoring of storm water quality.

Summary of Research Report No. 95

Project 73-3-12: MALVERN URBAN TEST CATCHMENT, VOLUME II - J. Marsalek, Environmental Management Service, Environment Canada

The Malvern urban test catchment was established in 1973 to provide field data on quantity and composition of runoff from a typical residential area. Such field data could be used for testing of urban runoff models and also for the assessment of the magnitude of problems caused by urban runoff.

This second progress report deals with a continuation of the Malvern field study in 1974. The terms of reference for the second year were as follows:

1) to collect data on rainfall and runoff quantity and quality in the Malvern catchment,
2) to reproduce selected observed runoff hydrographs by means of the SWMM model, and
3) to study the feasibility of simulating runoff quality in the Malvern catchment.

The principal findings of the study are summarized below.

Modifications of the Malvern catchment instrumentation, which were implemented during 1974, contributed to an improved quality of the collected rainfall/runoff records. In particular, good synchronization of rainfall and runoff records was obtained by recording both phenomena on a single strip chart. The accuracy of rainfall records was improved by calibrating the tipping bucket raingauge for various rain intensities.

About one-third of the 50 observed events was selected for further study. All these selected events were well documented and represented medium to high intensity storms. Comparison of rainfall and runoff volumes for these selected events indicated that a nearly constant proportion of rainfall was converted into runoff. It appears, therefore, that all the runoff was generated on impervious areas.

Seventeen observed runoff events were reproduced by means of the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) Runoff block. In model simulations, the catchment was represented by ten subcatchments and 21 sewer pipes. Hydrologic model parameters were set equal to the SWMM default values, with the exception of the surface storage depth on impervious areas. A depth of 0.5 mm (0.02 inches) rather than the default value of 1.5 mm (0.06 inches) was used as recommended in the first progress report.

The goodness of fit of simulated to observed runoff hydrographs was determined for three hydrograph parameters - the volume, peak flow, and time to peak. On average, the simulated runoff volumes were equal to the observed ones and about two-thirds of the simulated volumes were within 11% of the observed ones. The simulated runoff peaks were on average underestimated by about 3%. About two-thirds of the simulated peaks were within 14% of the observed ones. The simulated times to peak were on average underestimated by about 3%.

The accuracy of runoff simulations for the 1974 data is comparable to that reported in the first progress report. In both cases, the simulation accuracies are fairly good and fully acceptable from the practical point of view.

During 1974, the terms of reference of the study were expanded to include monitoring runoff quality. An automatic wastewater sampler was installed at the drainage outfall in late summer. This original installation was found unsatisfactory. Frequent equipment malfunctions resulted in a large loss of data. In fact, only five minor events were successfully monitored and documented for further study. The experience in runoff quality monitoring which was gained during this stage of the study was useful in redesigning the quality monitoring station and establishing data collection procedures in the subsequent years.

Quality of runoff events which were observed in the Malvern catchment were reproduced by means of the SWMM. The total event loads were reproduced quite well, but the actual shape of the observed pollutographs was reproduced rather poorly. The simulated pollutographs revealed very little variation in pollutant concentrations during the runoff events. Because of the limited data base, the testing of the SWMM presented in this report appears to be inconclusive and additional testing is recommended.

PROJECT SUMMARY

Project Title	:	Instrumentation for Field Studies of Urban Runoff
Scientific Liaison Officer:		J. Marsalek
Program Category	:	Solution Capability Development
Project Number	:	73-3-12
Funding Source	:	100% Canada-Ontario Agreement
Funding	:	FY 73/74 = $30.0 K
Contractor:		Environmental Management Service, Environment Canada
Contract Time	:	April 1973 to March 1974
Status of Reports	:	Published as COA Research Report No. 42. Work in the area covered by Project 73-3-12 was later moved to Project 74-1-40.

Description and Summary

The project examined instrumentation and monitoring techniques for field studies of urban runoff. In particular, the following types of instruments were studied:

1) recording precipitation gauges,
2) sewer flow measurement instruments, and
3) automatic wastewater samplers.

After reviewing the literature and surveying the market, the most promising instruments were acquired. These were tested in the laboratory and operated in the field for various time periods.

Individual instruments are discussed in the report with regard to their technical data, accuracy, and reliability. Recommendations for the selection, interfacing, and installation of the instruments are given.

Summary of Research Report No. 42

Project 73-3-12: INSTRUMENTATION FOR FIELD STUDIES OF URBAN RUNOFF -
J. Marsalek, Canada Centre for Inland Waters,
Environment Canada, Burlington, Ontario

The increasing urbanization of Canadian society has made a dramatic impact on water resources in the affected areas. Large areas of housing and pavement in urbanized regions reduce the infiltration of rain water into the ground and increase the surface runoff. Not only is the volume of runoff increased, the runoff water is polluted and, typically, is discharged into local receiving waters without treatment. Uncontrolled discharges from combined as well as separate sewers are recognized as one of the major contributors to the lowering of water quality in rivers and lakes.

Under the research program of the Urban Drainage Subcommittee (UDS), an urgent need for urban runoff data was identified and several data collection projects were initiated. The collected data will be used to assess pollution caused by urban runoff and combined sewer overflows, and for the planning, design, and operation of drainage systems, as well as for the development, calibration, and verification of storm water management models.

It became apparent in the preparatory stage of the UDS data collection program that, because of the stringent requirements for accuracy and detail in the collected data, the instrumentation to be employed had to be carefully selected if the program objectives were to be achieved. The Hydraulics Research Division of the Canada Centre for Inland Waters was authorized to assess the suitability of various conventional instruments and techniques for data collection in urban runoff studies. Following a literature survey, selected instruments for the monitoring of precipitation and runoff quantity and quality (by sampling) were acquired and tested in the laboratory as well as in the field. The results of these tests are presented in this report. Throughout the report, emphasis is placed on the general and practical aspects of data collection. For the design of special data acquisition systems, additional references are cited.

An assessment of the environmental impact of urban runoff on receiving waters requires detailed data on precipitation-runoff processes. Precipitation, runoff flow rate, and runoff quality are phenomena of major interest; consequently, the following types of instruments were studied:

1) recording precipitation gauges,
2) sewer flow measurement instruments,
3) automatic wastewater samplers.

Individual instruments are discussed with regard to their technical data, accuracy, and reliability. Recommendations for the selection, interfacing, and installation of the instruments are given.

The precipitation data required include point precipitation and the surface distribution of precipitation. Such information can be obtained from a network of several recording rain gauges installed within the study area. The tipping bucket rain gauge (0.01 inches) is particularly suitable for this purpose. A good time-resolution, frequently five minutes or better, is required.

Runoff flow rates should be recorded continuously at one or more points. Whenever feasible, runoff flows should be measured at the outfall, i.e., outside the sewer system. Conventional constriction flow meters such as weirs (inexpensive, but they block the transport of solids) or flumes (more expensive, but they allow the passage of solids) can be used. The acceptable accuracy of runoff flow measurements is five to ten percent.

If it is necessary to measure inside the sewer system and the sewer pipe is not frequently surcharged, an inexpensive trapezoidal weir without the bottom part or a flume may be used. For frequently surcharged pipes, a dual free-pressurized flow meter such as the U.S. Geological Survey Sewer Flowmeter should be used; an acoustic flow meter can also be used.

Runoff quality is commonly determined by the laboratory analysis of grab samples collected in the field. Such samples are collected sequentially by automatic samplers. A sampling interval as short as five to ten minutes may be required. The first sample should be collected as close to the beginning of runoff as practicable. The desirable size of samples is about 1000 mL. Great care must be taken to avoid systematic

errors in the sampling. It is therefore desirable to locate the sampler intake at a point in the flow where the sampled medium is relatively homogeneous. The capability of the sampling apparatus to collect solids should be evaluated, mainly with regard to the intake orientation and the intake nozzle and line velocities. To reduce the loss of quality data owing to sampler malfunctions, two samplers may have to be installed and operated in parallel.

A good time synchronization between the recordings of the precipitation, runoff flow and sample collection can best be ensured by recording all this information on the same chart or tape.

PROJECT SUMMARY

Project Title	:	Data Collection and Modelling at Brucewood, North York
Scientific Liaison Officer	:	J. Marsalek
Program Category	:	Problem Definition and Solution Capability Development
Project Number	:	73-3-12+, 74-8-4, and 75-8-34 Projects 73-1-32 also assisted these projects with sample analysis.
Funding Source	:	30% Environment Canada (EMS) 70% Environment Canada (EPS)

Funding	:	Project 73-3-12+	Project 74-8-4	Project 75-8-34
FY 73/74		EPS 7.7		
FY 74/75		EPS 9.4	EMS 6.0	
FY 75/76			EMS 6.0	EPS 10.9
Project totals		$17.1 K	$12.0 K	$10.9 K

Total	:	$40.0 K
Contractor	:	James F. MacLaren Ltd.
Contract Time	:	February 1974 - March 1976
Status of Reports	:	The reports on this project were originally written as Volumes I, II and III and these have been compiled into one report by the contractor covered by Project 77-8-43.

Description and Summary

The study objectives were:

1) to establish and equip with instruments an urban catchment;
2) to collect precipitation, runoff and snowmelt data in this catchment; and
3) to use these field data for verification of the U.S. EPA Storm Water Management Model.

A test catchment representing a modern residential area served by storm sewers was established and monitored over a two-year period.

Several observed events were used to verify the U.S. Environmental Protection Agency Storm Water Management Model (SWMM).

Project 73-3-12+. The objectives of this project were: to modify the existing runoff metering station to accommodate an automatic sampler and to operate it all year round; to collect storm water samples during runoff periods, the size of the sample to be determined on the basis of the parameters to be evaluated; and, to interpret the collected data on runoff quantity and quality. Samples were analyzed by the MOE laboratory. Work continued under Project 74-8-4 with EMS funding and under Project 75-8-34 with EPS funding. Project 73-1-32 provided laboratory analytical support for Project 73-3-12+.

Projects 74-8-4 and 75-8-34. The study objective was to collect data for the validation of a snowmelt model (quantity and quality) developed under the SWMM contract (Project 73-5-10). The data were collected on an urban area in North York (Brucewood) and consisted of the following: snowmelt runoff flow hydrographs; snowmelt runoff pollutographs; climatological data (precipitation and its distribution, hourly air temperatures and other data available from a nearby meteorological station); additional quality data for rainwater and catch basin contents, street sweepings and composite snow samples; and information on municipal practices, such as street cleaning, snow removal, application of abrasives and deicers, etc., during the period of the study.

PROJECT SUMMARY

Project Title	:	Bacteriological Monitoring at Burlington, East York, Guelph and North York
Project Leaders	:	B. Dutka, Environment Canada, and A. Qureshi Ministry of Environment
Scientific Liaison Officer:		J. Marsalek, F.A. Tonelli, and D.G. Weatherbe
Program Category	:	Problem Definition
Project Number	:	75-3-24, 74-8-25, 76-8-41
Funding Source	:	100 % Canada-Ontario Agreement

Funding :

	Project 75-3-24	Project 74-8-25	Project 76-8-41
FY 75/76	6.4	7.5	
FY 76/77		2.3	12.4
Totals	$6.4 K	$9.8 K	$12.4 K

Contractor	:	Environmental Management Service, Environment Canada, and the Ontario Ministry of Environment
Contract Time	:	July 1975 - March 1977
Status of Reports	:	The report on these three projects was published in one volume under the title "Microbiological Characteristics of Urban Storm Water Runoff in Central Ontario", COA Research Report No. 87.

Description and Summary

Project 75-3-24. Two instrumented sites, as indicated above, were used to obtain first hand information on the presence of standard bacteriological parameters and some pathogens in storm water. Runoff was monitored in different seasons and for different storm intensities. The type of information collected was directed towards assessing possible health hazards arising from the discharge of storm water.

Project 74-8-25. Two instrumented sites, as indicated above, were used to obtain first hand information on the presence of standard bacteriological parameters plus some pathogens in storm water. Runoff was monitored in different seasons and for different storm intensities. The type of information collected was directed towards assessing possible health hazards arising from storm water runoff.

Project 76-8-41. This project was a continuation of Projects 75-3-24 and 74-8-25, but in FY 76/77 the laboratory work was conducted only at the Canada Centre for Inland Waters. The objective of the project was to obtain information on standard bacteriological parameters in storm water plus data on pathogens which could readily be enumerated. Runoff was monitored in different seasons or at different storm intensities. The type of information collected was directed towards assessing possible health hazards in storm water runoff.

Summary of Research Report No. 87

Projects 75-3-24, 74-8-25, 76-8-41: MICROBIOLOGICAL CHARACTERISTICS OF URBAN STORM WATER RUNOFFS IN CENTRAL ONTARIO - Environment Canada and Ontario Ministry of the Environment

As a part of Urban Drainage Subcommittee (UDS) programs, three feasibility studies were designed to collect baseline data and information on the microbiological quality of urban storm water runoff by examining several storm sewers in southern Ontario.

The first study (COA Project 75-3-24) was carried out by the Microbiological Laboratories of the Canada Centre for Inland Waters (CCIW). During the six-month (June to November 1975) study period, the microbiological composition of storm water runoffs was examined in three areas having different land uses and drainage characteristics. These included one commercial area, Aldershot Plaza in Burlington, and two residential areas, Malvern Road, Burlington, and Brucewood subdivision,

---

NOTE: Analytical and survey data for the above projects may be obtained from J. Marsalek or James F. MacLaren Limited.

Borough of North York in Metropolitan Toronto. Samples, collected at various times during several storm events, were analyzed for pollution indicator bacteria (total coliforms, fecal coliforms, and fecal streptococci), pathogenic bacteria (Pseudomonas aeruginosa, salmonellae), total fungi, parasites, and coprostanol.

The second study (COA Project 74-8-25) was conducted by the Microbiological Laboratories of the Ontario Ministry of the Environment during September 1975 to February 1976. In this investigation, the incidence and distribution of pollution indicator bacteria, pathogenic bacteria, and total fungi were examined in storm water runoff samples collected every five minutes for a period of one hour during the course of a rainfall event. The source(s) of microbiological contamination and potential health hazards associated with storm water pollution were also evaluated. Several storm events were monitored at two sites with different topography and drainage characteristics. A residential area along Barrington Avenue in the Borough of East York in Metropolitan Toronto and a residential-commercial area in the vicinity of Woodlawn Road in Guelph were the sites studied.

The third study (COA Project 76-8-41) was also undertaken by CCIW Microbiological Laboratories from April to November 1976. This investigation specifically examined the occurrence and time-related distribution of pathogenic bacteria in storm water runoff samples collected at different time intervals over the first four-hour period of a rainfall event. In addition, the incidence of pollution indicator bacteria, heterotrophic bacteria, total fungi, Leptospira, and viruses was determined in these samples. A storm sewer outfall in the residential area of Malvern Road in Burlington was the site of this study.

Information regarding the sites examined, methods and techniques used, and the results and findings of these studies were documented in three separate reports. Although these investigations were conducted in diverse areas using three different approaches, they essentially dealt with a common subject. Therefore, the three reports were compiled to bring all data and comprehensive information on the microbiological characteristics of Canadian storm water runoffs under one cover. Some of the highlights and conclusions of these studies are summarized below.

1) High densities of pollution indicator bacteria (total coliform, fecal coliform and fecal streptococcus) were found in the storm water runoff samples collected from all five separate storm sewer systems examined.
2) High concentrations of heterotrophic bacteria and fungi, indicative of excessive organic enrichments, were present in all storm water runoffs.
3) Among the pathogenic microorganisms tested for, Pseudomonas aeruginosa was the most numerous and consistently recovered. Salmonellae were detected quite frequently both in the individual and composite storm water samples. Staphylococcus aureus were infrequently isolated and only in low numbers. No human pathogenic Leptospira were isolated. Only one sample, collected from the latter part of a storm event, was positive for a human pathogenic virus (reovirus).
4) Infiltration waters appeared to be a source of low level, but continuous, microbial pollution. Similarly sediments, which not only contained significant quantities of indicator organisms but pathogens as well, constitute a reservoir for various micro-organisms that ultimately find their way into storm water runoffs.
5) The levels of microbial populations in storm water runoffs were strikingly high and were similar to those encountered in dilute sewage, and therefore constitute a health hazard. The implied public health risks are substantiated by the consistent recovery of pathogenic microorganisms in discharges at the sites studied.
6) The results of these studies indicate that fecal pollution in the separate storm systems examined is predominantly of non-human origin. Fecal material from animals and birds washed into the systems during rain storms appeared to be the major source of microbial pollution.
7) There appeared to be little relationship between the intensity and amount of rainfall and the occurrence of indicator and pathogenic microorganisms. As a result, no typical patterns of distribution of these organisms in storm water runoffs could be

established in these studies. The peak microbial populations were found either at the initial stages, middle, or the tail-end of the sampling periods of different storm events monitored. Pathogenic bacteria were detected during all phases of the 240-minute sampling period in one study. The unpredictable distribution patterns and intermittent release of microorganisms in storm waters suggest that any effect of "initial flushing" on microbiological quality of storm water runoffs was minimal during an individual storm event. Therefore, to remove the health hazard and to improve the quality of discharges, the collection and subsequent treatment of a specific portion of each storm would be of little significance. This does not necessarily mean, however, that for removing and preventing health hazards, disinfection of all urban storm water runoff would be required. A more realistic and practical solution would be to treat all sanitary sewage overflows and discharges from those separate storm sewers where land uses and drainage characteristics (e.g., cross-contamination from domestic sewage) indicate the necessity for undertaking such an action.

8) These feasibility studies provided baseline data and significant information on the microbiological quality of storm water runoffs at several locations in central Ontario. In future, studies should be carried out to determine the nature and degree of microbiological loadings in receiving waters. Also, demonstration projects should be conducted to ascertain the most effective and economical remedial measures to prevent public health risks and deterioration of microbiological quality of surface waters receiving urban storm water runoff.

Projects No. 75-3-24, 74-8-25, 76-8-41

Authors: Microbiological Study at Some Canadian Storm Water Runoffs at Burlington and Brucewood - Project No. 75-3-24, B.J. Dutka and I. Rybakowski, Canada Centre for Inland Waters, Environment Canada, Burlington, Ontario.

Microbiological Characteristics of Storm Water Runoffs at East York (Toronto) and Guelph Separate Storm Sewers - Project No. 74-8-25, Ansar A. Qureshi, Laboratory Services Branch, Ontario Ministry of Environment, Toronto, Ontario.

Monitoring of Storm Water Runoffs for Bacterial and Viral Pathogens of Man - Project No. 76-8-41, B.J. Dutka and S. Tobin, Canada Centre for Inland Waters, Environment Canada, Burlington, Ontario.

PROJECT SUMMARY

Project Title	:	Storm Water Management Model Study
Scientific Liaison Officer:		J. Marsalek, G.H. Mills, and R.W. Slater
Program Category	:	Solution Capability Development
Project Number	:	73-5-10
Funding Source	:	32% Canada Ontario Agreement 68% Environment Canada (EPS)

Funding :

FY	$ K
74/75	178.1
75/76	25.1
Total	203.2

Contractor	:	Proctor & Redfern Ltd. and J.F. MacLaren Ltd.
Contract Time	:	May 1974 - March 1976
Status of Reports	:	Three reports were published on this project:

Volume I	COA Research Report No. 47
Volume II	COA Research Report No. 48
Volume III	COA Research Report No. 62

Description and Summary

The project objectives were:

1) to review and modify the U.S. EPA Storm Water Management Model for Canadian conditions;
2) to provide a submodel for simulation of quantity and quality of runoff resulting from snowmelt;
3) to provide a high-speed continuous simulation model for simulation of frequency of overflows and discharges; and
4) to develop a data analysis model capable of extracting the SWMM meteorological input data from the existing data banks.

Additional work activities included the development of a simplified quality model, study of equivalent catchments, update of engineering costs, and the development of guidelines for interfacing of

various runoff models. As a result of this project, the capabilities of the original SWMM were significantly expanded.

Two workshops were given on this project as COA Technology Transfer activities. Dates of the Workshops were: No. 1 Workshop, March 29-31, 1976; No. 2 Workshop October 19-21, 1976, published by COA as Conference Proceedings No. 4. See Appendix 1.

Summary of Research Report No. 47

Project 73-5-10: STORM WATER MANAGEMENT MODEL STUDY, VOLUME 1 - Proctor and Redfern Limited and James F. Maclaren Limited

This volume, Volume I of a three-volume report, describes the final results and conclusions of a study of storm water management models. The objectives of this study were:

1) to review and modify the U.S. Environmental Protection Agency Storm Water Management Model (SWMM) for Canadian conditions,
2) to select and modify a submodel for the simulation of quantity and quality of runoff resulting from snowmelt,
3) to develop a Data Analysis Submodel capable of extracting the SWMM meterological data input from existing data banks, and
4) to select and modify a high speed model for simulation of frequency of discharges and overflows, with the capability to use output from the Data Analysis Submodel as input.

The report is concerned with all aspects of storm water management and studies of model application and covers:

- basic concepts of storm water management modelling,
- scope and organization,
- assessment and selection of study areas,
- SWMM flow simulation for selected Canadian watersheds,
- SWMM quality simulations for selected Canadian watersheds,
- assessment of SWMM infiltration and receiving water body routines,
- storage/treatment routines,
- snowmelt quantity and quality,
- equivalent catchments (lumping),

- a generalized SWMM quality model,
- continuous simulation, and
- development of a meteorological data analysis processing program.

An analysis of the available measurements of storm water runoff events and combined sewer overflows on urban watersheds in Canada indicated that no one set of data was perfect for a general validation of all Storm Water Management Model (SWMM) routines. The comparison of measured flows with those simulated by the SWMM over a wide range of watersheds confirmed that the model predicts peak flows, time to peak, and total volumes sufficiently accurately for planning applications and for design work (when surcharge is not required).

The sophisticated Water Resources Engineers (WRE) transport routine incorporated in the SWMM and Dorsch Hydrograph Volume Method (HVM) model gave superior simulations to those using the initial SWMM transport routine for surcharged sewer systems. The results of the two routing models WRE and HVM, compared for similar systems using identical input flows, are considered to be equivalent.

The analysis of different urban runoff quality models indicated that the SWMM incorporates the most comprehensive quality routines of those reviewed. The accuracy in quality modelling was not comparable to that obtained in quantity modelling. The SWMM quality model, in calibration, gives order of magnitude estimates of peak pollution concentrations, and of the total pollutant load to the receiving water during a storm water discharge event.

Methods resulting in significant simplifications of both quantity and quality simulation procedures were developed for the computation of catchment outfall hydrographs and pollutographs. A generalized quality model based on equations used in SWMM was developed. This model requires less data preparation and computer processing time than the SWMM, and is capable of more rapid calibration.

Snowmelt quantity and quality submodels were integrated with the SWMM as user options. All of the other SWMM routines were tested and 'debugged', and subsequently assessed and/or modified. In particular, the

storage/treatment cost routine was adapted to include cost information based on Canadian data.

Comparison of the results of the Storage, Treatment, Overflow, Runoff Model (STORM) developed by the U.S. Corps of Engineers with those of detailed SWMM simulations emphasizes the fact that the very simple STORM is an excellent tool for predicting the quantity and the number of individual overflows from a particular district.

A new model for the processing and analysis of meteorological data for use with STORM and SWMM was developed.

The interfacing of the models investigated is discussed and a package of models capable of simulating all aspects of storm water flow and quality is presented. Emphasis is placed on the applicability to Canadian conditions, as well as on the level of sophistication appropriate to the different stages of a study, and on the selection of the right model for the job.

SWMM flow simulation was proven to be accurate in a large number of applications for areas of greatly differing size, land use and sewer system configuration, and over a range of meteorological conditions. Incorporation of the WRE transport routine extends the capabilities of the original SWMM to include the analysis of surcharged systems. Therefore, the use of SWMM is recommended for the simulation of flows in most drainage planning and design studies. Particular advantages offered by other models in certain specific situations should not be overlooked.

The use of STORM is recommended in planning studies for simulating the volume and number of overflows over the period of the long-term meteorological record. STORM should be used for the generation of statistical analysis of the effects of storage on reducing overflow volumes, and for a guide to the probable associated reduction in the total pollutant loads discharged. STORM is particularly useful for the screening and comparison of alternatives, and for the isolation of critical events for subsequent SWMM simulations.

It is considered that some sampling of the quality of runoff and overflows is usually required to supplement the final modelling activities in a study directed towards the design of pollution abatement facilities. Past experience with the interpretation of the results of sampling

programs, and subsequent efforts for calibration, have emphasized that the collection of samples should be very carefully planned in view of the high costs involved. Preliminary modelling often can prove useful in determining the specific sampling locations required.

Simulation of storm water quality will be useful in a variety of studies such as the assessment of requirements for upgrading treatment plants, the need for new plants, the benefits of sewer separation or new interceptors, and the control of runoff from new developments. It is recommended that quality and quantity modelling form an integral part of all studies for pollution abatement.

Particular advantages of the SWMM are its wide availability, the excellent training program offered, and, most importantly, the potential for the study of both quantity and quality throughout the urban system and in the receiving waters.

Implementation of modelling techniques will be most successful if the advantages and limitations of different models are understood. The interfacing of models outlined in the report, such as the complementary use of STORM and SWMM, is considered an example of the hierarchical use of models for different stages of a project.

Summary of Research Report No. 48

Project 73-5-10: STORM WATER MANAGEMENT MODEL STUDY, VOLUME II - Proctor and Redfern Limited and James F. MacLaren Limited

Volume II of this three-part report might be considered as a supplement to Volume I, as it contains background material relating to the first volume. Volume II contains the following:

1) comparative analysis of routing models,
2) comparative analysis of water quality models,
3) literature survey - urban runoff quality,
4) literature survey - snowmelt quantity,
5) literature survey - snow quality,
6) data collection - study areas, and
7) treatment processes.

As a result of the extensive literature survey in Section 3, it was obvious that sources of contaminants in urban storm water could include street litter, gas combustion products, de-icing salts and chemicals, rubber and metal lost from vehicles, decaying vegetation, domestic pet wastes, fallout from industrial and residential combustion products, and chemicals applied to lawns and parks. Wide variation has been found in the values for various pollution parameters examined at different locations. Determining factors include land characteristics of the catchment, intensity of vehicular traffic, the antecedent dry period, street cleaning practices, frequency and efficiency of street sweeping, population density of the catchment, and storm characteristics.

Many of the sophisticated models for snowmelt modelling require a large amount of meteorological data as input. Also, the more accurate models generally require calibration of several parameters. However, most urban locations have first-order meteorological stations, and data required could be obtained from the data bank of the Atmospheric Environment Service, and Environment Canada. A more important consideration with respect to snowmelt modelling is the computational accuracy required.

Of the various contaminants generally found in deposited snow and snowmelt water, chlorides and lead are reported to be the most serious and potentially hazardous pollutants. The mean chloride levels found in different cities in Canada ranged from 191 to 13325 mg/L. Lower values were obtained for residential streets: higher values for highways. A maximum lead concentration of 113 mg/L was measured on a major highway in Ottawa.

A summary of the treatment processes available in SWMM is given, as well as a review of current literature and modifications to the treatment model.

Treatments which have been incorporated into the SWMM include:

1) storage/sedimentation,
2) screening and filtering units,
3) concentrating units,
4) biological treatment, and
5) disinfection.

Summary of Research Report No. 62

Project 73-5-10: STORM WATER MANAGEMENT MODEL STUDY, VOLUME III (User's Manual) - Proctor and Redfern Limited and James F. MacLaren Limited

The Canadian study, detailed in Volumes I and II of the SWMM study (COA Research Reports No. 47 and 48, respectively), has expanded the capabilities of the original SWMM. Volume III is a manual that presents the expanded SWMM in a form suitable for practical use.

Methods of aggregating the properties of individual subcatchments into a single equivalent catchment are described. These can lead to a considerable reduction in data preparation and computer processing time. A generalized quality model has been developed based on SWMM equations and using the simplification in the aggregating techniques. Snowmelt quantity and quality models have been integrated with the SWMM. Methods of interfacing the SWMM and STORM (U.S. Army Corps of Engineers) have been discussed and demonstrated, and a fully operational package of models, capable of simulation of all aspects of storm water flow and quality, has been prepared for application to Canadian conditions.

User information on the setup and operation of the entire model, as well as setup and use of the individual program blocks, is presented in this manual. Reference is made to the U.S. Environmental Agency User's Manual where necessary to avoid duplication.

PROJECT SUMMARY

Project Title	:	The Effect of Storage on Storm and Combined Sewers
Project Leader	:	J.G. Henry
Scientific Liaison Officer	:	D.J. Hay
Program Category	:	Solution Capability Development
Project Number	:	74-8-1
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 74/75: $6.6 K
Contractor	:	University of Toronto
Contract Time	:	February 1974 - October 1974
Status of Reports	:	Published as COA Research Report No. 34

Description and Summary

The primary objective of this study was to compare the economic and environmental features of a combined and separate sewer system. This study was carried out using a new residential development of four hectares (10 acres) as a basis for the formulation of the model. The task was divided into three stages:

1) A literature review of sewer system design was carried out with emphasis on reducing combined sewer outflow.
2) An analysis of design and cost data and an investigation of various alternative storage methods, such as on-site storage on roofs and in underground tanks and in-line storage in underground structures and holding reservoirs, were conducted.
3) Cost and performance comparisons among the alternative solutions were made.

Summary of Research Report No. 34

Project 74-8-1: THE EFFECT OF STORAGE ON STORM AND COMBINED SEWERS -
J.G. Henry and P.A. Ahern, Department of Civil Engineering, University of Toronto

Combined sewers designed to accept both sanitary flows and storm water flows have provided the means of wastewater collection in many urban areas of Canada for over 100 years. Conventionally, interceptor sewers with capacities 1.5 to 5 times greater than required for dry weather flows are used to divert combined flows to a water pollution control plant for treatment before discharge to a water body. During storms, flows in excess of interceptor capacities are discharged directly to the receiving waters.

In recent years, there has been a growing concern with the pollution problems caused by combined sewer overflows. It has been estimated that by 1980 the average five-day BOD loadings on Lake Ontario from overflows in Metropolitan Toronto may reach 600 tons/month, almost one-half the anticipated total loading. As overflows occur for only a few hours each month, the shock loadings generated by individual storms will be much greater than the average loading.

Current practice favours separate sewer systems as a means of alleviating overflow pollution problems. Sanitary wastes are collected, transported, and treated separately in order to eliminate discharges of raw sewage. Generally, the storm sewer network is extended only to a suitable watercourse and storm water flows are discharged without treatment.

For densely populated areas presently served by combined sewers, separation costs may be prohibitive. A study of a 6880-ha area (17 000 acres) in the City of Toronto in 1960 indicated that the costs of sewer separation could be about $42 000 per hectare ($17 000 per acre). For new developments in unsewered areas, there may be substantial savings in provision of a single conduit to serve as a combined sewer. The cost of a separate system for unsewered areas of Detroit has been estimated at twice the cost of a combined system.

This report describes a study of the effect of storage on storm and combined sewers in a residential subdivision of approximately 100 acres under development in southern Ontario. The storage methods examined were:

1) ponding of rainfall on flat roofs;
2) on-site storage of roof runoff;
3) storage of flows from street gutters at catch basins; and
4) holding reservoirs as part of the sewer network.

A hydrograph model for estimating storm water runoff from residential areas was developed and incorporated in a computer program. The model was used to determine the outflow hydrograph at the storm sewer outfall from the subdivision for a synthetic two-year design storm. An alternative design, replacing the separate sanitary and storm sewers by combined sewers, was carried out and the outflow hydrograph from a combined sewer network was determined. The effects of different storage methods on the outflow hydrograph were tested for both the separate and combined systems.

Cost data from the original separate system design were used to calibrate formulas for estimating sewer pipe costs. The total costs of systems incorporating various storage options were compared.

The cost of combined sewers for the 41.1-ha (101.6-acre) subdivision studied in this research was estimated to be only slightly less than the total cost of sanitary and storm sewers. If higher full-flow velocities are required for combined sewers than for separate storm sewers, the use of combined sewers in new developments may not be justified. However, choice of the wastewater collection system for any area would be governed ultimately by factors particular to that area, such as topography.

The savings in sewer costs resulting from the incorporation of storage in the subdivision were found to be quite small for both storm and combined sewers. Reduction in volumes of untreated overflow to receiving waters is a further benefit when a combined sewer system with storage is used.

Roof pounding to eliminate roof runoff was found to reduce peak sewer flows from the subdivision by up to 30 percent and catch basin storage provided similar reductions. Because of different flows to each of the catch basins, storage volumes for a constant outflow varied from zero up to a maximum of 42.5 m^3 (1500 ft^3).

Holding reservoirs proved to be the most effective means of modifying storm water flows from the subdivision. A graphical relationship between storage volume and peak flow was developed for a holding reservoir, enabling storage requirements for any level of peak flow reduction to be estimated.

The rational method, which considers only average rainfall intensity for a selected rainfall duration, was found not suitable for the design of sewer systems incorporating storage. The runoff model developed to compute complete sewer low hydrographs from a design storm, when tested, produced results consistent with field data from other sources.

PROJECT SUMMARY

Project Title	:	Urban Drainage Model Comparison for a Catchment in Halifax, Nova Scotia
Project Leader	:	D.H. Waller
Scientific Liaison Officer	:	D.J. Hay
Program Category	:	Solution Capability Development
Project Number	:	74-8-2
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 74/75: $3.6 K
Contractor	:	Nova Scotia Technical College, Halifax, Nova Scotia
Contract Time	:	April 1974 - March 1975
Status of Reports	:	Published as COA Research Report No. 43

Description and Summary

The objective of this study was to evaluate the relative merits of the Runoff block of the U.S. EPA Storm Water Management Model and the British Road Research Laboratory Model. The project was designed to evaluate the performance of the two models using runoff data collected for a previous project. Simulation capabilities of the models to translate rainfall into runoff were judged.

Summary of Research Report No. 43

Project 74-8-2: URBAN DRAINAGE MODEL COMPARISON FOR A CATCHMENT IN HALIFAX, NOVA SCOTIA - D.H. Waller, W.A. Coulter, W.M. Carson, and D.G. Bishop, Nova Scotia Technical College

Rainfall-runoff data were collected for a 67.7-ha (167.2-acre) combined sewer drainage area at Halifax, Nova Scotia. These data were used to compare the performance of the U.K. Road Research Laboratory (RRL) runoff model and the RUNOFF block of the U.S. Environmental Protection Agency Storm Water Management Model.

Halifax rainfall is not typical of most populated parts of Canada and the United States, where rainfall intensities are higher and pervious areas may contribute significantly to runoff. Pervious areas do not contribute to runoff, and runoff volume varies linearly with rainfall, for most storms on the Halifax catchment. In major storms pervious areas make a minor contribution to runoff.

Both the EPA and RRL models demonstrated the capability of producing credible results when they were applied to a sewerage system that exhibited features they were not designed to represent. The resemblance between the results of the two models was more pronounced than the resemblance between observed and calculated results. The RRL model tended to generate more pronounced peaks, with faster rise and recession, than the EPA RUNOFF block. This effect was particularly apparent in small storms and in the low flow portions of larger events.

In most storms, calculated peaks were earlier and larger than observed values. Agreement between calculated and observed hydrographs improved with the magnitude of storm events. Differences between observed and calculated results could not be explained by errors in recorded hydrographs or in subtraction of base flows.

Artificially steepened slopes were used in the models for a number of pipes known to be surcharged in the actual system, permitting both models to function without the effects of surcharging. The effect of this assumption on the shapes of calculated hydrographs was masked by the influence of other factors on hydrograph shapes. The effect of the inability of the RRL Model to represent pervious area runoff was also obscured by the effects of other factors influencing the shape of hydrographs calculated in this study.

The report recommends that caution be exercised in assuming values for input variables for either the RRL model or the EPA RUNOFF block unless these values have been validated by experience on other basins, or by calibration of the models for the basin that is under consideration.

Computer time requirements, and corresponding costs, for running the EPA RUNOFF block were considerably greater than the time and cost of running the RRL model. Time and cost could be reduced by "lumping" of subcatchments.

PROJECT SUMMARY

Project Title	:	Winter Runoff from an Urban Catchment
Project Leader	:	W.A. Coulter and D.H. Walter
Scientific Liaison Officer	:	D.J. Hay
Program Category	:	Solution Capability Development
Project Number	:	74-8-3
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 74/75: $7.7 K
Contractor	:	Nova Scotia Technical College, Halifax, Nova Scotia
Contract Time	:	March 1974 - May 1975
Status of Reports	:	Published as COA Research Report No. 41

Description and Summary

This project was a continuation of previous work on a 66-ha (163-acre) Halifax catchment. The objectives of this research were to study the effects of snowmelt runoff on the quality and quantity of combined sewage, and to form a data base which could be used for the future verification of storm water management models. The study was divided into three main areas:

1) New gauging and sampling sites were established and the data collection was expanded.
2) Chemical and bacteriological analyses were undertaken by either the Nova Scotia Technical College or the Nova Scotia Pathological Institute.
3) Precipitation quantity data (rainfall, snow depth and density) and accumulated snow in curbside banks were collected and analyzed. Snow removal and street sweeping practices, the accumulation and composition of dirt, sand and salt applications, and so on were also studied.

Summary of Research Report No. 41

Project 74-8-3: WINTER RUNOFF FROM AN URBAN CATCHMENT - D.H. Waller and W.A. Coulter, Nova Scotia Technical College

Existing urban wastewater management models are unable to represent quantity and quality variations resulting from snowmelt or winter rainfall. The models have been developed in areas where either snowmelt and frozen ground conditions were irrelevant or because adequate data were not available to provide a sound basis for model development. This study attempted to provide some of the information that will be needed if adequate models of wastewater variations during winter conditions are to be developed.

The objective of the project was to extend earlier work on a 66-ha (163-acre) combined sewer drainage area in Halifax to include consideration of quality and quantity variations due to snowmelt and winter runoff. This report presents results and assessments in terms of their application to the development of quality and quantity models.

Information about winter runoff and snowmelt was obtained from January to March of 1974. Limited amounts of data were obtained for: precipitation; dustfall; snow quantity, quality, and density; amount and composition of street solids accumulation and of sand used for ice control; composition of runoff due to snowmelt and rainfall; and, composition and flow rate of dry weather flow and combined sewage. Factors that affect quality and quantity variations in winter runoff are discussed in relation to annual and seasonal variations and in terms of their application to development or testing of runoff and quality models for urban areas.

The information obtained will be of value in quantifying and testing models which represent variations in the amount and composition of surface runoff and combined sewage both on a seasonal basis and during storms.

More information is needed, however. It could be obtained from continuous flow measurements and regular sampling of both combined sewage and surface runoff during a complete winter season, together with complete records of meteorological and other factors which contribute to runoff flow

and composition. The report indicates areas where additional information is required or where data collection procedures could be improved. When the information obtained is applied, further suggestions about future work will undoubtedly emerge.

Throughout this project, continuous liaison was maintained with City of Halifax staff, and full cooperation and access to records were provided by them, but available information proved to be inadequate in terms of detail and precision. Planning for future projects should make certain that adequate city or project staff are available and that city procedures are organized to ensure that complete and precise records of city works practices are maintained.

PROJECT SUMMARY

Project Title	:	Collection of Field Data in the Borough of East York, Toronto, Ontario, for the Verification of the Storm Water Management Model
Supporting Project is	:	73-1-32, for analytical work
Scientific Liaison Officer:		D.G. Weatherbe
Program Category	:	Solution Capability Development
Project Number	:	74-8-5
Funding Source	:	19% Canada-Ontario Agreement 81% Environment Canada (EPS)

Funding :

FY	$ K
74/75	22.5 (EPS)
75/76	24.0 (EPS)
76/77	22.5 (EPS)
77/78	16.2 (COA)
Total	85.2

Contractor	:	M.M. Dillon Ltd.
Contract Time	:	October 1974 - March 1977
Status of Reports	:	Published as COA Research Report No. 97.

Description and Summary

The details collected in this project augmented the data base for verification of the U.S. EPA's Storm Water Management Model (SWMM) with modifications for Canadian conditions. The SWMM was verified on the test area by means of comparison of model predictions with field measurements. Individual events were recorded for hyetograph(s), hydrograph(s) and pollutograph(s). The data collection exercise was designed in such a way that, in its final form, the base is compatible with SWMM. The points that ensure maximum utility of the study are:

1) selection of a normal area,
2) availability of the hydrogeometrics of the area and details of hydraulic elements of the sewer system,

3) selection of a central location for collecting climatological data,
4) location of instrumentation of the sewer from the viewpoint of accessibility and economics,
5) documentation of municipal practices such as street and sewer cleaning, deicing, etc., and,
6) analysis of monitored events.

The instrumentation of the site was completely automated. The samples collected from the selected combined sewers were analyzed at the MOE laboratory. See Project 74-8-6 for the work statement of a similar project in Hamilton.

Summary of Research Report No. 97

Project 74-8-5: STORM WATER MANAGEMENT MODEL VERIFICATION STUDY - M.M. Dillon Ltd.

The report describes the main aspects of a study to calibrate and verify the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) for an urban catchment area. Details of the selected area, the instrumentation used, and of the results obtained are presented and discussed. The data obtained from selected storm events are compared with simulated hydrographs and pollutographs generated by the SWMM. It is concluded that these simulations of real storm events, with respect to both runoff flow and water quality, are very good when compared to those obtained in other studies.

The selected 155-ha (383-ac) urban catchment in the Borough of North York, Toronto, is an older residential area served by a combined sewer system and is, therefore, well-suited for combined sewer urban runoff studies.

In setting up the data acquisition system for the selected study area, it became apparent that the selection of, and the method of operating, a data acquisition system is very site-specific. The data acquisition system described in this report performed well for the first 1½ years after the inevitable teething troubles had been sorted out. In the later stages of the study period, however, wear and tear caused some equipment failure resulting in a few sizeable gaps in the recorded data.

A substantial amount of collected data on temperature, precipitation and dry and wet weather flow has not been presented in this report. It is, however, available from the Ministry of the Environment (Water Modelling Section of the Water Resources Branch) and would be extremely useful for further studies such as calibration and verification attempts on the CANSWMM snowmelt routine.

The quantity verification results are most encouraging. The simulated flow volumes of the rainfall events were underestimated by about 3% on average; 32 simulated peaks were overestimated by about 2% on average and 32 simulated times to peak were overestimated by about 3% on average. Unfortunately, in most of the monitored rainfall-runoff events the rainfalls were of relatively low intensity. As a result, virtually all the recorded runoff originated from the impervious areas and consequently the Storm Water Management Model could only be verified for this condition. Although this is a major shortcoming, the good verification results obtained in this study do indicate that the SWMM can be a fairly accurate tool for predicting the quantity of runoff from an urban catchment area providing that it is first calibrated. There is also every reason to assume that the same encouraging verification results can be obtained for higher intensity storms with proper calibration. This assumption is reinforced by the reasonable results obtained in attempts to calibrate input parameters related to pervious areas for the three storms with fairly high rainfall intensities.

The quality verification results can be considered as reasonable. They could most likely be improved by carrying out an intensive recalibration process with particular emphasis placed upon the method of computing suspended solids and/or the adjustment of the dust and dirt loading rates and pollutant composition. It was concluded that, when simulating the quality of runoff for real storm events from catchment areas in which the streets are swept frequently and/or at irregular intervals, special consideration must be given to the method by which the model computes the dust and dirt accumulation.

On the whole, the verification results can be rated as very good when they are compared with those of similar studies. It is concluded that this can be attribued to one or a combination of the following factors:

a) a well-defined catchment area and the fairly accurate determination of the basic physical characteristics;

b) a fairly detailed division scheme for the catchment area and sewer network;

c) the good quality and the completeness of the recorded data.

Of the above factors, the good quality of the recorded data was probably the most influential in achieving the encouraging verification results. This is because the sensitivity of the Storm Water Management Model demands that the recording instruments have a time resolution of about one to two minutes, and that the various recording components be accurately synchronized. These criteria were met in this study.

It is important to note that, throughout this study, a time step of five minutes was used for the hyetographs. Because the Storm Water Management Model is extremely sensitive, it is felt that a change in the time step to say, two minutes, could substantially change the simulation results. Consequently, it can only be said that in this particular study, the Storm Water Management Model was calibrated and verified for hyetographs discretized in five-minute time steps.

PROJECT SUMMARY

Project Title	:	Collection of Field Data in Hamilton, Ontario, for the Verification of the Storm Water Management Model
Supporting Project is	:	74-8-26, for analytical work
Scientific Liaison Officer	:	J. Marsalek
Program Category	:	Solution Capability Development
Project Number	:	74-8-6
Funding Source	:	25% Canada-Ontario Agreement 23% Environment Canada (EMS) 52% Environment Canada (EPS)

Funding :

FY	$ K
74/75	21.6 (EPS)
75/76	18.1 (EMS)
75/76	0.4 (EPS)
76/77	17.5 (EPS)
76/77	3.2 (COA)
77/78	16.2 (COA)
Total	77.0

Contractor	:	Gore & Storrie Limited
Contract Time	:	October 1974 - June 1976
Status of Reports	:	Published as COA Research Report No. 99

Description and Summary

The information collected under this project augments the data base for the verification of the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) modified for Canadian conditions. The model was verified on the test area by means of comparison of model simulations and field measurements. The individual precipitation-runoff events were described by hyetographs, runoff hydrographs and pollutographs. These data were supplemented by some additional information on the test area as needed for the application of the SWMM. A summary of the work statement follows:

1) to collect precipitation, runoff, and other field data needed for the verification of the Storm Water Management Model on the Hamilton test catchment,
2) to present collected data in a format compatible with the SWMM requirements and provide other related information,
3) to simulate major runoff events using the SWMM and compare the results with observations,
4) to report the findings of the study.

See Project 74-8-5 for the work statement of a similar project in Toronto.

Summary of Research Report No. 99

Project 74-8-6: STORM WATER MANAGEMENT MODEL VERIFICATION - HAMILTON TEST CATCHMENT - Gore and Storrie Ltd.

A residential test catchment in Hamilton, Ontario was selected and equipped with a data acquisition system for the collection of data on rainfall and the quantity and quality data of urban runoff. The test catchment is served by a combined sewer system and comprises an area of 71-ha (176-acres).

The description of the hydrologic and physical characteristics of the watershed, the criteria adopted for the selection of the instrumentation system, the installation of the instrumentation, and the data collection procedure are detailed in the report.

The results of data analysis and the calibration and verification results of the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) are discussed in detail and are presented in tabular and graphical forms. These results confirm the reliable performance of the SWMM runoff quantity model as indicated by the reasonable agreement of the simulated hydrographs with observed values. On the other hand, the calibration efforts with the adapted version of the quality model to achieve agreement between the measured and the simulated pollutographs, on an event basis for some pollution parameters, did not produce acceptable correlation.

The selected test catchment met most of the required criteria for collecting the pertinent physical data and the rainfall-runoff data.

However, construction activity within the test catchment during part of the flow monitoring period had an adverse influence on some quality parameters, such as suspended solids.

The level of reliability of service of the instrumentation system was very good, especially during extremely adverse weather and temperature conditions. In addition, the synchronizing of different records for a given event was better than average. The automatic sampler had an inherent delay in starting which forestalled the gathering of quality data at early stages of all the recorded events. This could not be rectified during the course of the data collection period.

The dry weather flow data obtained for the watershed was not sufficient to obtain the relevant average values for quantity and quality parameters. The installed flow measuring system was not adequately sensitive to accurately measure these flows. A measuring weir installed across the trunk sewer possibly changed the normal deposition and resuspension pattern of the dry weather flow pollutants. A reliable record of rainfall and runoff data was compiled for a number of events covering a broad range of rainfall volumes for this test catchment.

The variations between the simulated and observed results for the initial SWMM quantity modelling, when studied, furnished valuable information, especially helpful in view of the large number of input data variables involved, to formulate the calibration methodology. The calibration efforts confirmed the importance of the use of RUNOFF block input variables as calibration parameters. To achieve a calibration result of wider application, it was advantageous to use the results of a number of events rather than a single event.

The observed runoff volumes for longer duration high-volume rainfalls were found to be significantly increased by extraneous inflows into the sewers other than DWF and surface runoff contributions. The base flows for such events were evaluated by a subjective extention of antecedent flows during the calibration efforts. If calibration is based on the requirement of closer agreement of results for higher rainfall events, then the model will furnish an upper level limiting curve of runoff volumes for a range of events including lower rainfall values

during verification. These results tend to agree most closely with observed thunderstorm events, which is of more practical value.

The initial analysis of observed pollutographs generally showed the "first flush" in storm water runoff. The influence of the antecedent dry period in determining the pollutant concentrations was evident for a number of events. Construction activity substantially increased the suspended solid loading. The effect of resuspension of sewer deposits was evident from the initially high volatile solids loading rates.

The attempts at calibrating the quality modules resulted in inadequate levels of agreement for a number of events (pollutants BOD and SS, which are vital indicators of storm water pollution) with very conservative assumptions for default values. The net indicative conclusion of these efforts is that any additional modelling should be attempted only on the latter versions of the quality model, as the discrepancies encountered in the present attempt with the earlier version are not encouraging.

PROJECT SUMMARY

Project Title	:	Review of Problems in Combined and Partly Combined Sewerage Systems in the Province of Ontario
Scientific Liaison Officer:		P. Seto
Program Category	:	Implementation Strategy Development
Project Number	:	74-8-9
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 76/77: $19.6 K
Contractor	:	Gore & Storrie Limited
Contract Time	:	December 1975 - March 1976
Status of Reports	:	Published as COA Research Report No. 93

Description and Summary

The objective of this project was to identify, assemble, screen, and assess reports commissioned by the Ministry of the Environment or municipal governments relating to the entire sewerage systems of combined or partly combined sewer systems. Only reports comprehensive in scope were used, and emphasis was given to reports from cities with a high sanitary sewerage flow ascribed to combined sewers. The problems observed were studied taking into consideration factors such as topography, soil conditions and urban population. Case problems were investigated in selected locations using historical background information, date of commencement of sewer separation, reasons for the separation program, and discussion of regulatory and fiscal constraints.

Summary of Research Report No. 93

Project 74-8-9: REVIEW OF PROBLEMS IN COMBINED AND PARTLY COMBINED SEWERAGE SYSTEMS IN THE PROVINCE OF ONTARIO - Gore and Storrie Limited, Toronto, Ontario

The objective of this project was to research background information relating to combined and partly combined sewer systems in Ontario. In phase 1 of the project, reports on combined and partly combined sewer systems were identified, assembled, screened and assessed. Problems in reported "case histories" were emphasized in phase 2. Solutions of the problems and implementation procedures were proposed for six municipalities, and government and professional opinions were solicited.

To assess the extent of problems within combined and partly combined sewerage systems, to determine their geographical distribution, and to locate reports dealing with them, information was collected by means of a questionnaire. A 77 percent response was obtained from the 245 municipalities which received the questionnaire. In addition, 33 reports on sewer systems in 26 municipalities were analyzed.

An attempt was made to correlate combined sewer problems under the following seven categories:

- geographical correlation,
- topographical correlation,
- soils character,
- history of sewer development,
- economic base,
- urban populations and densities,
- population development factors.

Although all these factors influenced the development of municipal sanitary systems, and particularly the prevalence of combined sewers and their problems, no significant trends could be identified.

Municipal officials appeared to be primarily concerned with quantitative rather than qualitative problems. The concern of provincial regulatory agencies with the qualitative problems of pollution and erosion from combined sewer overflows was not matched at the municipal level. The most prevalent problems indicated by the municipalities included:

- infiltration and inflow,
- basement flooding,
- overflows,
- overloading,
- by-passing, and
- area flooding.

The effect of combined sewer overflows on receiving water quality did not appear to be a municipal concern.

The in-depth "case history" studies were made from information obtained in local interviews and from collected sewer reports and other related documents. Although the same factors played a similar role in the development of sanitary sewers, combined sewers, and their associated problems in all municipalities, the main system conditions and problems tended to be specific for each case.

PROJECT SUMMARY

Project Title	:	Design Demonstration of SWMM at Merivale
Scientific Liaison Officer:		D.J. Hay
Program Category	:	Solution Capability Development Implementation Strategy Development
Project Number	:	74-8-10
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
75/76	3.5
76/77	11.9
77/78	2.1
Total	17.5

Contractor	:	Gore and Storrie, Ltd.
Contract Time	:	1975 to 1978
Status of Reports	:	Project shared on a 50/50 basis with the Regional Municipality of Ottawa Carleton. Published as COA Research Report No. 89.

Description and Summary

An attempt was made to establish the quantity of pollutants that might be discharged from the Merivale storm sewer trunk system into the Rideau River, and to determine feasible and economical methods of controlling these pollutional loads. Initially, the flow and pollutional characteristics of the storm water runoff from the proposed Merivale trunk sewer were investigated to determine the present and ultimate conditions. An attempt was made to study the capabilities of various treatment components and options in reducing the pollutional loads. A trial of the Infilco "Hydro-Brake" has been made by the Environmental Protection Service, Environment Canada, Ottawa, the contractor being Gore and Storrie Ltd. funded by Canada Mortgage and Housing Corporation.

Summary of Research Report No. 89

Project 74-8-10: STORM WATER MANAGEMENT FOR NEPEAN, MERIVALE AREA - Gore and Storrie Limited, Toronto, Ontario

A detailed analysis of the quantity and quality of storm runoff from the Merivale area of Nepean, Ontario, to the Rideau River was carried out. The Merivale area watershed comprises 526 ha (1300 acres) of industrial (285.3 ha) residential (54.6 ha), and open land (186.1 ha). An open ditch storm drainage system collects and transports runoff from the originally developed areas to Nepean Creek, and ultimately to the Rideau River. The newly developing area of Merivale Acres Industrial Colony is serviced by storm sewers which drain to a three-metre (120-inch) diameter main trunk sewer routed through the development area. A main trunk and local sewer system plan has been developed to service the entire area. The Rideau River has been identified by the Ontario Ministry of Environment as a particularly sensitive watercourse with a limited ability to assimilate polluting discharges.

The Storage, Treatment, Overflow, Runoff Model (STORM), developed by the U.S. Army Corps of Engineers, was used in this analysis for continuous simulation of rainfall and runoff based on hourly precipitation data. The Storm Water Management Model (SWMM), developed by the U.S. Environmental Protection Agency, was used to simulate specific storm events. These models generated quantity and quality information for storm runoff from the area. Based on this information, three storm water management control and treatment alternatives were prepared. Estimated costs for the proposed control and treatment alternatives are provided in the report.

Conclusions and Recommendations

1) The application of storm water management controls to provide surface ponding and storage on impervious areas of new development lands would produce beneficial results with respect to reduced loadings to the Rideau River. Although the effect would be most noticeable in the individual areas where the controls are applied, the effect of the reduced loadings from the entire watershed would be significant. The application of these

controls to the new development areas (121.4 ha or approximately 23% of the watershed) would reduce total pollutant washoff from the watershed for a specific storm by five to eight percent. It is recommended that such controls be applied and proper management of such controls be enforced for all new developments.

2) The provision of a storm water retention pond to receive the drainage from the Merivale Gardens residential subdivision and the National Capital Commission Greenbelt would noticeably reduce pollutant loadings from the watershed. The storm water retention pond would reduce total pollutant washoff from the watershed by five to seven percent.

   It is recommended that the construction of a storm water retention pond within the Greenbelt be considered in developing the sewer system. It is also recommended that the National Capital Commission be approached with respect to property requirements for such a ponding facility.

3) The analysis showed the dramatic effect of pollutant buildup on streets and impervious areas associated with antecedent dry days. For similar storm events, washoff of pollutants increased approximately three times when antecedent dry days increased from 17 to 25 days. It is recommended, therefore, that the City of Nepean review its street sweeping policy with a view to increasing the frequency of sweeping to once every two weeks for this watershed.

4) The pollution washoff loadings predicted for the Merivale watershed were derived using the STORM and SWMM. Calculated loadings, as predicted by the models, are based on average values measured in a number of cities, particularly in the United States. Actual values experienced in the Merivale area may, therefore, vary significantly from those predicted. The model simulations, however, do provide a good representation of the relative effects and merits of the various storm water management alternatives investigated.

It is recommended that a detailed monitoring system be installed to more accurately assess the magnitude of pollutant washoff from the watershed for the various antecedent conditions and also to assess the effects of increased development and extension of servicing. The results of such a monitoring system would provide the necessary data to assist in decision-making for possible additional storage and/or treatment requirements.

5) The analysis showed that a storage/treatment facility with a capacity of two million imperial gallons would contain the runoff from the majority of storm events and provide sedimentation for additional removal of pollutants. It has also been shown that a storage volume of approximately 7274 m^3 (1.6 MIgal) could be provided within the existing trunk sewer for the present scope of development. This available storage will, however, decrease to approximately 3 178 m^3 (0.7 MIgal) as development increases and sewer services are extended to provide additional sewer capacity.

It is recommended that the monitoring program include an analysis of the effectiveness of this trunk sewer storage volume. The data from such a monitoring program and analysis would be most useful in determining actual requirements for additional subsurface storage and treatment.

6) The analysis investigated the relative effects of various forms of treatment including:

a) plain sedimentation,
b) sedimentation assisted by chemical coagulation,
c) swirl concentrator,
d) combination of above.

The model simulation showed the relative effectiveness of various treatment options, particularly for SS and BOD removal. The effectiveness of various options in removing coliforms, however, has not been well documented. The model simulation provided estimates of total coliform counts in the washoff from the watershed, but the numbers of fecal coliform and fecal streptococci associated with such washoff cannot be predicted.

It is recommended that the monitoring program include bacteriological analysis. This will permit an assessment of the magnitude of coliform counts expected and provide the needed data to assist in decision-making for possible additional treatment requirements.

7) The water quality guidelines set by the Ontario Ministry of the Environment have been formulated in the absence of any regional watershed analysis to assist in establishing total predicted loadings to the Rideau River and the capability of the river to assimilate such loadings. The MOE has suggested that such a study be undertaken to establish a more realistic policy and set of guidelines.

A regional study of the scope suggested by the MOE would be of great value in formulating a more realistic set of quality guidelines for storm water runoff to the Rideau River.

PROJECT SUMMARY

Project Title	:	Physical Treatment System for Storm Water
Project Leader	:	F.A. Tonelli
Program Category	:	Solution Capability Development
Project Number	:	74-8-14
Funding Source	:	100% Environment Canada
Funding	:	FY 76/77: $0.6 K
Contractor	:	Ministry of the Environment
Contract Time	:	July 1975 - March 1976
Status of Reports	:	No report was published in conjunction with this project. Information resulting from the project is included elsewhere in COA publications.

Description and Summary

The study was carried out by a combination of literature review, discussions with officials in the EPA and other United States Agencies, and visits to demonstration projects. The project had the following objectives:

1) to determine the performance, availability, relative capital and operating costs of the various systems,
2) to evaluate individual installations from the viewpoint of potential wider applicability,
3) to examine the extent to which existing equipment design criteria and sewage characteristics at existing installations are adequate to predict performance and cost in other locations, and
4) to determine the extent and scale of pilot and demonstration test-work necessary in new locations using the currently available design criteria.

PROJECT SUMMARY

Project Title	:	Practices, Policies and Technology of Storm and Combined Sewers in Foreign Countries
Scientific Liaison Officer	:	D.J. Hay
Program Category	:	Implementation Strategy Development
Project Number	:	74-8-17
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 74/75: $36.3 K
Contractor	:	Albery, Pullerits, Dickson & Associates Ltd.
Contract Time	:	September 1974 - March 1975
Status of Reports	:	Published as COA Research Report No. 45

Description and Summary

The objectives of this research were:

1) to investigate the European experience of pollution problems associated with storm sewer discharges and combined sewer overflows;
2) to study foreign statutory policies governing storm discharges and overflows; and
3) to study the present design practices covering methods of problem identification.

The work included: discussions on the recognition of the scope of the problem; a literature survey to become familiar with the European situation; contact with external consultants to acquire details of regulatory powers and research being carried out; preparation of comprehensive questionnaires to assist data collection and forwarding of these to the appropriate authorities in five European countries - Great Britain, France, Germany, Sweden and Switzerland; and supplementation of the questionnaire data through consultation with engineers in the above

countries. A contract amendment further provided for review of storm water management policies in the United States. This is also included in the final report.

Summary of Research Report No. 45

Project 74-8-17: PRACTICES, POLICIES AND TECHNOLOGY OF STORM AND COMBINED SEWERS IN FOREIGN COUNTRIES - Albery, Pullerits, Dickson and Associates Ltd., Don Mills, Ontario

This study was undertaken to evaluate pollution problems associated with storm sewer discharges and combined sewer overflows in several European countries and the United States. Current methods used to abate pollution from these sources and research underway to develop new methods were also investigated.

Since the magnitude of the problem and the approaches to its solution vary in each country according to the relationships between various levels of government, citizen action groups, industry, and research groups, it was necessary to review the governmental structures, historical aspects, and present design criteria for all contributory features of storm and combined sewers in the countries studied.

Questionnaires were distributed to local authorities, government departments, research organizations and consulting engineers in the United States, Sweden, France, the United Kingdom, Germany, and Switzerland. In addition, research engineers visited installations in each country and interviewed key personnel.

This report reviews the information obtained during the study and assesses the various methods of combatting pollution from storm and combined sewers, both in the context of the countries concerned and in relation to the Canadian situation.

The present status of storm water practices in other countries is summarized below under separate headings for each country studied.

United States: A massive pollution correction program with a target date of 1983 has been established. The interim goal is the protection of fish, shellfish, and wildlife and the preservation of recreational activities in or on the water. The federal government has taken the lead;

it has passed the necessary laws and approved funding which will enable it to work with state or inter-state authorities in achieving the necessary goals. A large volume of research has been and is being undertaken, and the problem of storm water management is now better understood in the United States than in any other country.

Sweden: Considerable progress has been made in Sweden in controlling the pollution from sanitary and industrial sewage, and the country is now coming to grips with the storm water problem. Considerable effort has been expended in keeping abreast of foreign research and in seeking unusual solutions to problems which are peculiar to the Scandinavian environment. The central government is instrumental in setting the standards for policies and ensuring adequate funding for research projects.

France: In France pollution problems have not been considered as critical as in other countries because other needs for reconstruction have, of necessity, taken priority. A massive program for the construction of sanitary sewage treatment facilities is also in progress; consequently, few funds are available for the correction of the storm water pollution problem, which is relatively insignificant in comparison to that of the sanitary system.

United Kingdom: The relatively limited water resources of the United Kingdom have become severely strained by pollution from various sources and a continuous effort has been made in the past several years to clean up both sanitary and industrial pollution. A considerable improvement has been effected, and this, together with the extensive coastline, has created a situation where storm water flooding is regarded as being more critical than storm water pollution. The management of the water resources in the country has been entirely decentralized so that local areas are now responsible for their own water management. It is also apparent, from the mapping of river pollution, that the most severe problems are generally restricted to the industrial Midlands.

Germany: The pollution problems of the waterways of Germany have been evident in the industrialized, densely populated sections of the country. Considerable improvements have been effected, but here too the demands

of post war reconstruction have resulted in some delays in the construction of new facilities. The balance of power between the Federal and the Lander governments has also retarded the establishment of a unified program for the entire country. Even so, the significance of storm water and overflow pollution is recognized, and the federal government is pressing for the construction of more detention tanks and is making funds available for extensive research. Where conditions are most severe, the formation of conservation authorities by contiguous local authorities has resulted in the construction of treatment plants, the control of pollution and, in at least one case, the treatment of an entire river.

Switzerland: Surface water pollution in Switzerland has for many years been kept very much under control. A grant system which enables any municipality to construct the treatment facility appropriate to its particular circumstance has enabled the entire country to be maintained in a relatively clean condition. The awareness of the need to control pollution and the desire to maintain an attractive country has resulted in requirements that industries provide covered storage for unsightly and surface polluting materials and generally control and treat discharges in an appropriate manner.

The report includes the following recommendations for the control of storm water quantity:

1) the complete division of storm and sanitary sewers in new and developing areas, and examination of the potential for unregulated discharge of storm water into natural water courses to increase flood hazards;
2) the identification of flood plains;
3) the establishment of sufficient data collection stations to monitor storm intensities, durations, and movements;
4) the development of drainage criteria through the evaluation of experimental drainage sections in new developments;
5) the control of on-site detention of water by private, industrial or commercial developments.

Recommendations on the control of storm water quality include:

1) the development of policies for the treatment of combined sewer overflows;
2) the assessment of the costs and benefits of street cleaning procedures;
3) the comparison of costs and effects of separate sewer systems and other alternatives to determine the most appropriate procedure;
4) the production of maps defining critically polluted surface waters; and
5) the determination of the pollution potential of storm runoff from new construction and development.

The report also includes recommendations for the management of storm water flooding and quality. Priority is given to applied research, on-site investigations, and proper planning in the early stages of development.

PROJECT SUMMARY

Project Title	:	Technical Advisory Services from Charles Howard and Associates Limited
Scientific Liaison Officer:		T.S. Munro
Program Category	:	Problem Definition, Solution Capability and Implementation Strategy Development
Project Number	:	74-8-18
Funding Source	:	100% Environment Canada (EPS)

Funding :

FY	$ K
73/74	9.5
74/75	13.5
75/76	20.0
Total	43.0

Contractor	:	Charles Howard and Associates Ltd.
Contract Time	:	May 1974 - March 1976
Status of Reports	:	No report issued on this project

Description and Summary

Charles D.D. Howard graduated from the University of Alberta in 1960 and has advanced degrees from the University of Alberta and the Massachusetts Institute of Technology. Mr. Howard's professional experience includes work for Canadian and United States consulting firms and government agencies on research and engineering of hydro-electric and tidal power projects, integrated electrical power system planning, and runoff and water quality studies in urban areas.

As a technical advisor to the subcommittee he was required:

1) to provide advice to the project scientific liaison officers for efficient and effective integration of the SWMM and other related study areas;
2) to provide ongoing evaluation of the results of all studies and to develop recommendations;

3) to provide advice and assess the implications of developments in related areas in other countries; and

4) to assist the development of expertise in the federal and provincial levels of government.

PROJECT SUMMARY

Project Title	:	Technical Advisory Services from D.H. Waller
Scientific Liaison Officer:		T.S. Munro
Program Category	:	Problem Definition, Solution Capability and Implementation Strategy Development
Project Number	:	74-8-20
Funding Source	:	100% Environment Canada (EPS)

Funding :

FY	$ K
74/75	9.7
75/76	16.1
76/77	17.5
77/78	10.0
Total	53.3

Contractor	:	D.H. Waller
Contract Time	:	June 1974 - March 1977
Status of Reports	:	No report issued on this project.

Description and Summary

As a technical advisor, D.H. Waller was required:

1) to provide advice to scientific liaison officers for efficient and effective integration of the SWMM and other related study areas;
2) to provide ongoing evaluation of the results of all studies and to develop recommendations;
3) to provide advice and assess the implications of developments in related areas in other countries; and
4) to assist in the development of expertise in the federal and provincial levels of government.

Dr. Waller is a civil engineer with advanced degrees in Public Health Engineering (London) and biology (Dalhousie). He has been a professor in the Department of Civil Engineering, Nova Scotia Technical College, since 1961. He served as Deputy Director of the American Society of Civil Engineers Combined Sewer Separation Project in 1966-1968.

PROJECT SUMMARY

Project Title	:	Evaluation of the Magnitude and Significance of Urban Storm Water Runoff in Ontario
Scientific Liaison Officers:		T. Koplyay and D.G. Weatherbe
Program Category	:	Problem Definition, Solution Capability Development
Project Number	:	74-8-21
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY / $ K 74/75 / 10.3 75/76 / 45.1 Total / 55.4
Contractor	:	American Public Works Association (APWA) Chicago, Ill.
Contract Time	:	1974 - 1976
Status of Reports	:	Published as COA Research Report No. 81

Description and Summary

The project was directed towards defining quantity and quality characteristics of pollution loadings from storm and combined sewers. The objectives were:

1) to prepare a planning estimate of the quantity and quality of urban runoff contributions to the Great Lakes Watershed,
2) to develop cost estimates of implementing control and abatement practices with present day technology, and
3) to transfer the methodology employed in the analysis.

The study provided a rough estimate of the minimum cost of reducing pollution loadings from sewers for different treatment levels. From these cost estimates, storage/treatment strategies for various technological alternatives may be developed.

The STORM, developed for the U.S. Army Corps of Engineers, was applied to ten urban watersheds which drain into the Great Lakes. The results obtained were interpreted and extrapolated as required to indicate total pollution.

Summary of Research Report No. 81

Project 74-8-21: EVALUATION OF THE MAGNITUDE AND SIGNIFICANCE OF URBAN STORM WATER RUNOFF IN ONTARIO - R.H. Sullivan, W.D. Hurst, and T.M. Kipp, American Public Works Association and The University of Florida

In 1975 the American Public Works Association and the University of Florida conducted a study for the Urban Drainage Subcommittee of the Canada-Ontario Agreement on Great Lakes Water Quality. The study was conducted by using methods and procedures developed for a similar study in the United States. Information was supplied directly from the Ontario Ministry of the Environment, Environment Canada, and field interviews conducted in ten representative cities. The characterization of urban storm water runoff and combined sewer overflows was taken from the United States study and modified slightly for conditions in Ontario. Information concerning pollution from snowmelt was obtained from Canadian studies.

Storm water modelling using the complete U.S. Army Corps of Engineers' STORM for four small cities, and similar methods for an additional 52 cities, were used to determine storm flows and potential pollution loads. Relationships were developed between population density and pollution control costs for separate and combined sewered areas. Based upon an assumed cost and availability of land by population density, optimization of storage versus treatment was considered.

Control of pollution has been generally limited to evaluation of BOD, although it is known that other parameters are being controlled at the same time to various degrees of efficiency. The approach used could be adapted for these other quality parameters.

An important aspect of water quality planning is the tradeoff involved in the decision-making process when alternatives such as advanced dry-weather treatment and control of storm water or combined sewer overflows are under consideration. The study indicates that a significant portion of the wet-weather pollution should be controlled prior to initiation of advanced wastewater treatment.

The study found that local officials in Ontario were very concerned with flood control aspects of storm flow and less concerned

with quality aspects. Information required for detailed individual model studies was not available and there were no plans being made to gather information on key parameters. Local officials should, therefore, be made aware of the importance of pollution from urban storm water runoff and combined sewer overflows, and the significance of such polluted discharges compared with their present discharge of treated effluents from wastewater treatment plants.

The storage requirements necessary to economically treat storm flow may also serve to alleviate local flooding problems. Also, the gathering of data for storm water modelling would be of direct benefit in the planning and improvement of the drainage system, a readily perceived benefit.

Although the cost calculations may not be accurate for an individual city, they are reliable for preliminary assessments when considering the total urban drainage to the Great Lakes from the province of Ontario.

The following conclusions were made:

1) Local flooding due to hydraulic overloading, infiltration/inflow, deposition of solids, and untreated by-passes were the most common concerns of city officials with their storm water control systems.
2) Interest in modelling storm water runoff exists, particularly with regard to quantity predictions; however, the necessary resources to conduct studies are not available.
3) A characterization study of urban land use patterns found distribution of developed land use in urban areas to be:

Residential	52.5%
Commercial	10.3%
Industrial	14.0%
Other	23.2%

4) Based on available data the extent of combined sewer systems was determined for 49 of the 56 cities.
5) The loading factors used to calculate pollution loadings were based upon a study of available applicable data. However, the

overall impact of various sources on receiving water quality has not been evaluated in the urban setting. Research is needed to determine the effects of the following on wastewater quality: snowmelt, wear products from street surfaces, urban sediments and erosion products, tree and leaf litter, and accumulation from non-street impervious areas.

6) Primary treatment devices using physical processes such as screening, settling, and flotation have been developed and tested for application to combined sewer overflows. Their application to urban storm flows should be equally effective. A BOD removal efficiency of 40 percent appears reasonable.

7) For urban areas of over 10 000 population, from which drainage is into the Great Lakes, the annual cost of providing 25 percent BOD removal from urban storm flow and combined sewer overflows using secondary treatment and storage is estimated at $10 861 000, and for 50 percent control, $31 744 000.

8) Secondary treatment devices which use biological and physical-chemical processes are suitable for treating both combined sewer overflows and urban storm flow. Contact stabilization is feasible only if the dry-weather flow (DWF) facility is of an activated sludge type. A BOD removal efficiency of 85 percent appears reasonable.

9) The annual cost of providing 75 percent BOD removal for urban storm flow and combined sewer overflows using secondary treatment and storage is estimated to be $95 471 000.

10) Most DWF facilities offer an opportunity for treating wet-weather flow (WWF). The optimum mix of facilities must be determined on a case-by-case basis.

11) The optimal cost for WWF facilities is a function of the size of the facility, the unit cost of which decreases with size, and the cost of conveying the flow to the facility, a cost which increases with the size of the facility. Such determinations must be made for specific sites.

12) The optimal sizing of treatment and storage facilities will vary for each area and for the level of control required.

13) For BOD removals of less than or equal to 10 percent, the optimal treatment strategy is to use primary treatment devices for a portion of the flow. Secondary treatment devices are required for higher levels of control.

14) The relationship between level of control and number of overflow events can be predicted by methods which were developed.

15) To achieve 50 percent BOD removal, intensive control of combined sewer overflows results in a lower marginal cost than control in storm sewer areas.

16) Operation and maintenance costs will be affected by the number of hours that the facility is operated. The amount of storage which is provided allows a smaller capacity treatment facility, which will operate for a longer period of time, to achieve the same relative treatment. Annual operation and maintenance costs have been assumed to be 20% of the total costs of the treatment facility. Actual costs will vary with the type and size of the individual treatment units.

17) The first flush, a high concentration of pollutants in the first portion of the runoff, has a significant effect on cost assumptions. Control costs are about one-third less if a first flush is assumed.

18) The cost-benefit relationship between tertiary treatment of DWF and provision of WWF facilities needs to be investigated prior to instituting either control measure. It was found that about 16 percent of the storm flow should be controlled before initiating tertiary treatment if additional removal of organics is the purpose of tertiary treatment.

19) Rooftop and parking lot storage, surface and underground tanks, and storage in treatment units are effective flow attenuation control alternatives. The cost of providing such facilities will vary.

20) The unit costs of pollution control are lowest in the unsewered areas because of relatively low storage costs.

PROJECT SUMMARY

Project Title	:	Hydraulics of Sewer Pipe Connections and Junctions
Project Leader	:	J. Marsalek
Program Category	:	Solution Capability Development
Project Number	:	74-8-22 and 73-3-13
Funding Source	:	44% Canada-Ontario Agreement 56% Environment Canada (EMS)
Funding	:	FY / $ K 73/74 — 9.9 74/75 — 12.5 Total — 22.4
Contractor	:	Canada Centre for Inland Waters, Environment Canada
Contract Time	:	April 1973 - March 1975
Status of Reports	:	Project was continued after 1974 by Hydraulics Division CCIW without Urban Drainage support. A report is in preparation relative to the subcommittee's area of interest on both work done under Project 73-3-13 and 74-8-22 expected 1980.

Description and Summary

The main objectives of the study of the sewer pipe junctions were the following:

1) to evaluate the energy losses at conventional junction manholes,
2) to modify the conventional sewer junctions to reduce the energy losses evaluated above,
3) to study the control of combined sewer overflows by improving hydraulic efficiency, and
4) to improve the capacity of sewerage systems by increasing the hydraulic efficiency of various system components.

PROJECT SUMMARY

Project Title	:	Laboratory Analysis at Canada Centre for Inland Waters to support Project 74-8-6 (Collection of Field Data for SWMM)
Scientific Liaison Officer:		J. Marsalek
Program Category	:	Solution Capability Development
Project Number	:	74-8-26
Funding Source	:	19% Canada-Ontario Agreement 53% Environment Canada (EMS) 28% Environment Canada (EPS)

Funding :

FY	$ K
74/75	10.0
75/76	12.2
76/77	12.0
77/78	8.0
Total	42.2

Contractor	:	Canada Centre for Inland Waters, Environment Canada
Contract Time	:	April 1975 - March 1978
Status of Reports	:	No report issued on this project.

Description and Summary

Laboratory work to support Hamilton area data collection contract by Gore and Storrie Ltd. (Project 74-8-6).

PROJECT SUMMARY

Project Title	:	Man-Year Contribution to Program of the Urban Drainage Subcommittee by Environment Canada
Scientific Liaison Officer:		R.W. Slater
Program Category	:	Problem Definition, Solution Capability and Implementation Strategy Development
Project Number	:	74-8-27
Funding Source	:	100% Environment Canada

Funding :

FY	$ K
74/75	17.0
75/76	25.0
76/77	30.0
77/78	30.0
Total	102.0

Contract Time	:	April 1974 - March 1978
Project Status	:	Continuing at level of one man-year throughout the Urban Drainage Program, paid for by EPS-Ontario Region, Environment Canada.
Status of Reports	:	No report has been issued on this project.

Description and Summary

The man-year (supplied by COA) provides a program coordinator for the Urban Drainage Subcommittee Program. Duties involve project progress review, program analysis, and all tasks normally assigned to a project scientific liaison officer. Reports are also made to the Subcommittee on matters assigned for Working Group review.

PROJECT SUMMARY

Project Title	:	Pilot-Scale Evaluation of a Physical-Chemical Wastewater Treatment System for Combined Sewer Overflows
Scientific Liaison Officer:		A. Netzer
Program Category	:	Solution Capability Development
Project Number	:	74-8-29
Funding Source	:	100% Environment Canada (EMS)
Funding	:	FY 73/74: $15.9 K
Contractor	:	Pollutech Pollution Advisory Services Limited
Status of Reports	:	Report has been published as COA Research Report No. 36

Description and Summary

A microscreen pilot unit on a combined sewer overflow was set up and evaluated. The feasibility of using inorganic and organic chemical additives for phosphorus removal was determined. Chemical and bacteriological parameters were measured across the system. The effects of snowmelt runoff on the performance of the system were assessed.

Based on the findings of this research, cost estimates for a full-scale treatment system for efficient low-cost treatment of combined sewer overflows have been prepared.

Summary of Research Report No. 36

Project 74-8-29: PILOT SCALE EVALUATION OF A PHYSICAL-CHEMICAL WASTEWATER TREATMENT SYSTEM FOR COMBINED SEWER OVERFLOWS - Pollutech Pollution Advisory Services Ltd., Oakville, Ontario

Obvious deterioration in the quality of the Great Lakes watershed has led to re-evaluation of the practice of discharging untreated wastes to the natural watercourse. A significant source of contaminants is the overflow from combined sewage collection systems under storm conditions.

A large number of municipalities in the Great Lakes Region are served by such combined sewer systems, which transport both sanitary wastes and storm runoff waters.

Numerous systems, including separate sewer systems, storm water detention ponds, and in-stream physical and chemical treatment schemes have been proposed as means of controlling or reducing this pollutional load. This report deals with the applicability and feasibility of advanced physical-chemical treatment concepts, consisting of fine screening and ozonation, for high-rate treatment of wastes from combined sewer overflows.

The primary objective of the investigation was to assess the potential of the microscreen-ozone system for the high-rate treatment and abatement of pollution resulting from combined sewer overflows.

The first phase of the study encompassed the following:

1) the design, installation, and debugging of a pilot-scale treatment system consisting of a microstrainer and ozonation facilities, and evaluation of the applicability of the system for treating combined sewer overflows as simulated by diluted raw sewage,
2) an evaluation of the feasibility of using inorganic and organic chemical additives prior to microscreening as a means of precipitating phosphorus,
3) an evaluation of the effectiveness of ozone for disinfection and polishing of the screened sewage,
4) an evaluation of the ability of ozone to remove lead contaminants entering the sewage system from snowmelt runoff, and
5) the preparation of an approximate cost estimate for a full-scale treatment system.

The pilot-scale system consisted of a Crane-Cochrane Microstrainer with 23 micron screen openings and an ozone generator.

During the first part of the study, the pilot unit was installed at the West Oakville Water Pollution Control Plant. The dilute waste concentrations anticipated in combined sewer overflows were simulated by diluting raw sewage with tapwater. The parameters measured were BOD, total organic carbon, suspended solids, total phosphorus, oil and grease, and total coliforms.

The effects of waste strength and hydraulic loading were studied by varying the dilution of the raw waste and controlling the throughput of the unit.

An increase in the sewage suspended solids concentration resulted in a decline in the microstrainer performance. Contaminant removal efficiency also decreased when the hydraulic loading was increased beyond the design rating.

The effect of ferric chloride and polyelectrolyte chemical addition prior to microscreening was investigated, but no beneficial effect on the treatment efficiency was observed. This could have been a result of inadequate mixing conditions or inherent deficiencies in the system for the removal of chemical floc.

Ozonation was found to reduce the concentration of all measured contaminants including suspended solids. At an ozone dosage of 20 mg/L, in a continuous ozonation reactor with a nominal 15 minute retention time, COD removals of 40 to 50% were observed. Batch ozonation of the screened effluent resulted in greater than 99.9 percent reduction in the concentration of total coliforms.

During the second part of the study, the pilot-scale system was installed at a combined sewer outfall in Hamilton, Ontario and the efficiency of the system was evaluated in terms of the removal of BOD, suspended solids, total coliforms, total phosphorus, oil and grease, and total organic carbon from actual combined sewer overflows during three separate storms. The actual combined sewer overflows were found to contain a higher concentration of inorganic solids, primarily finely dispersed clay particles, and significantly less organic contaminants than were found with the synthetic waste used in the first part of the study.

The average overall efficiency of the pilot scale treatment system for all runs under actual operating conditions was 29.2 percent BOD removal, 29.6 percent suspended solids removal, 76 percent total coliform reduction, and 39.4 percent oil and grease removal. The removal in terms of all measured parameters was less than that attained by the system applied to the synthetic waste during the first part of the study. The absolute decrease in removal was from 6 to 38 percent.

No correlation was noted during the second part of the study between the hydraulic loading of the microscreen or the suspended solids content of the raw feed and the performance of the microstrainer in terms of suspended solids removal.

The results of the simulated and actual runs indicated that the system has good potential for this application. However, further work is recommended before any decision concerning the feasibility of full scale treatment of combined sewer overflows by this system is made.

PROJECT SUMMARY

Project Title	:	Development and Evaluation of Urban Runoff Computer Models and Review of Canadian Design Practice
Scientific Liaison Officer	:	J. Marsalek
Program Category	:	Solution Capability Development
Project Number	:	74-8-31
Funding Source	:	100% Environment Canada (EMS)
Funding	:	FY 73/74: $50.0 K
Contractor	:	J.F. MacLaren Ltd.
Contract Time	:	May 1973 - April 1974
Status of Reports	:	Published as COA Research Report No. 26

Description and Summary

The investigation consisted of two parts. A review was made of current Canadian storm sewer design practice with regard to hydrologic methods, storm frequencies and magnitudes, sewer sizing, sewer design, etc. The review was conducted by surveying consulting engineers and municipalities throughout the country. An analysis of the effectiveness of design methods employed was performed. In the second part of the project, the following urban runoff computer models were assessed using existing rainfall/runoff data:

1) U.S. EPA - Storm Water Management Model,
2) British Road Research Laboratory Model,
3) Unit Pulse Model,
4) University of Cincinnati UCUR Model,
5) HVM Model (theoretical analysis),
6) Rational Formula Design (for comparison purposes).

Summary of Research Report No. 26

Project 74-8-31: REVIEW OF CANADIAN DESIGN PRACTICE AND COMPARISON OF URBAN HYDROLOGIC MODELS - James F. MacLaren Ltd., Toronto, Ontario

The objective of the project was to investigate the possibility of applying new storm water management techniques and hydrograph runoff models in Canada. The study described in this report was oriented in two directions.

A survey of Canadian design practices in urban drainage systems was carried out. Needs for improved techniques, availability of means for the implementation of new hydrologic methods, and awareness of new trends in storm water management, as indicated by a review of the state-of-the-art, were the primary considerations. The survey also included other items of possible interest to municipal engineers. A questionnaire was distributed to municipalities across Canada requesting details of their storm sewer design practice with emphasis on policies, problems with flooding and frost conditions, and attitudes towards new trends in urban drainage management. Replies from 37 municipalities from Vancouver to Halifax were received and analyzed.

A comparative assessment of runoff hydrograph models was conducted. This part of the study was based, primarily, on measurements of test areas in the United States and Canada. The five urban hydrologic models evaluated were:

1) The Storm Water Management Model (SWMM),
2) The University of Cincinnati Model (UCUR),
3) The Transport and Road Research Model (RRL),
4) The Queen's University Urban Runoff Model (QUURM),
5) The Proprietary Dorsch Consult Hydrograph Volume Method Model (HVM).

An evaluation of the Rational Method was also included. The results presented in this volume are intended for the general information of those working in storm sewer design. Detailed mathematical developments regarding the different models have been avoided and can be found in the references by those interested.

The models were evaluated using recorded data from four residential test areas in the United States and Canada, using from 10 to 14 different storm events on each area. The accuracy and consistency of the models were assessed by means of graphical and statistical comparisons of peak flow, times to peak, runoff volumes, and the complete hydrograph for the computed and recorded hydrographs.

The peak flows calculated by the Rational Method were also compared with the measured flows. It was found that all models performed satisfactorily when applied to small test areas and that all of the models gave more consistent results than the Rational Method.

The key to the implementation of new management methods is the use of improved hydrologic tools. The design of storage, for example, which is the simplest method for reduction of flow peaks, is possible only through the synthesis of hydrographs. Storage in an urban system is not necessarily concentrated in a reservoir but may be distributed over different elements of the watershed such as parking lots, roofs, elements of the sewer network, and so on. Other methods of peak reduction are the retardation of flow by reduction of velocity or increase of infiltrated volumes. The traditional design method for drainage systems, the Rational Method, is aimed at providing only design peak flows and cannot be used for the study of management techniques. Even the use of the Rational Method for the derivation of design peak flows has been subject to criticism.

An increasing number of more sophisticated models dealing with urban storm water runoff is being developed. Some of these include quality considerations. A list of recent models is given in the report. The selection of a model, even if only runoff is considered, is obviously a difficult task. Many of the new models are at an initial or developmental stage, and most of the references regarding proprietary models give only limited information. During this study, it was found that, even for non-proprietary models, the selection of appropriate models required the assistance of the model builder or consultants with previous experience in their application and, eventually, some modifications to the models as well. Comparative analyses of the models prior to the beginning of this

study were limited and the adequacy of the most easily available models was determined by only a few comparisons with measurements. These conditions add to the confusion created by different publications advocating one model or another and could slow down the implementation of new storm water management techniques.

Urban drainage practice in North America is in a transition stage. There are many attempts being made to apply new concepts, such as: different types of storage, runoff limitation, and a uniform analysis of major and minor drainage systems. New simulation methods are increasingly applied in preference to the Rational Method.

Replies to questionnaires revealed that the most frequent problems in Canadian municipalities are associated with flooding. However, few cities reported serious difficulties in this regard. In general, smaller cities appear to have more problems with flooding than larger centres. At present, the Rational Method continues to be applied to storm drainage design in Canada, whether for northern or southern conditions. Wide discrepancies in parameters from city to city not only reflect differences in local conditions but also illustrate the degree of subjectivity associated with this method. It is difficult to estimate which designs are more conservative, since a large design storm may be used in conjunction with a small runoff coefficient.

Although most of the Canadian cities have design criteria, only 50% use standards specific to their own conditions. Standards are, in general, oriented toward traditional drainage practices. Twenty-one out of the thirty-seven cities replying to the questionnaire have in-house, or access to, computer facilities, but computers are currently used for storm sewer design in very few cities. Only eight of thirty-seven municipalities considered detention in storm sewer design; however, fifteen cities felt that research on detention is required, but only six rated this an area of high priority. Other management problems often considered to be of high research priority are pollution and land use planning.

Canadian municipalities have a widespread interest in new urban storm water management techniques and new computer models. However, it appears that more information regarding the interrelation between new hydrologic modelling techniques and new management techniques is needed.

The results of evaluating the models using a large number of storm events clearly indicated that the possible errors resulting from the use of the models are larger than indicated in the available literature. The possibility of errors is even greater with the Rational Method, however. The report concludes that the models are sufficiently well developed, at present, to give satisfactory results for practical applications, especially for the implementation of new management techniques for which the Rational Method is totally unsuitable.

The Road Research Laboratory Model (RRL) has the advantage that it is simpler than the other models and the disadvantage of not considering the runoff contribution of pervious areas. This contribution can become significant when the percentage of imperviousness is low, the area large, or the rainfall intensities high, as with a design storm.

The University of Cincinnati Urban Runoff Model (UCUR) has the most accurate surface routing routine for impervious surfaces of the three models considered. A logical error in the determination of depression storage supply on pervious areas and, especially, the use of a simple time offset sewer routing technique are serious drawbacks for applications to large areas.

The Storm Water Management Model (SWMM) gave the best overall performance of the models considered. Although the manner of calculating the surface flow rate tends to overestimate the detention storage, thus retarding the runoff, this can be corrected by the judicious choice of compensating parameters such as pipe roughness. The SWMM has the advantages of a more sophisticated pipe transport routine, compatability with an existing quality model, as well as continued updating and improvement through on-going research and practical applications in the United States.

The Queen's University Urban Runoff Model (QUURM) gives results as good as the SWMM and has the advantage of requiring the calibration of only one parameter. This model is also very suitable for the study of the effects of urbanization on surface runoff. Although there is little practical experience with the QUURM, at present, and the documentation has not yet been completed, this model can be applied effectively to storm sewer design, especially when coupled with an accurate transport routine.

PROJECT SUMMARY

Project Title	:	Municipal Pollutant Loadings to the Great Lakes from Ontario Communities
Project Leader	:	D. Novak
Scientific Liaison Officer:		D.G. Weatherbe
Program Category	:	Problem Definition, Solution Capability Development
Project Number	:	75-8-33
Funding Source	:	100% Environment Canada

Funding :

FY	$ K
75/76	2.3
76/77	8.2
77/78	11.9
Total	22.4

Contractor	:	Ontario Ministry of the Environment
Contract Time	:	April 1975 - March 1976
Status of Reports	:	Published as COA Research Report No. 94

Description and Summary

The objective of the study was to fund (in-house) EDP support of SWMM, STORM, and other applicable analytical tools in drainage planning and design. The activities familiarized MOE staff with computer models in urban drainage. Additionally, technology transfer functions will be served by improving in-house expertise.

A major application has been the modelling of urban runoff pollutant loads to the Speed River from the City of Guelph using water quality and quantity data collected from two urban catchments in the city and from the river upstream and downstream of the urban area. Data was collected as part of the Grand River Basin Study and also the Pollution from Land Use Reference Group (PLUARG) of the International Joint Commission.

Summary of Research Report No. 94

Project 75-8-33: MUNICIPAL POLLUTANT LOADINGS TO THE GREAT LAKES FROM ONTARIO COMMUNITIES - D.H. Waller, Nova Scotia Technical College, Halifax, N.S. and Z. Novak, Ontario Ministry of the Environment

The Urban Drainage Subcommittee, under the Canada-Ontario Agreement on Great Lakes Water Quality, in the problem definition phase of its program supported an "Evaluation of the Magnitude and Significance of Pollution Loadings from Urban Storm Water Runoff in Ontario" (COA Research Report No. 81). That work, which was carried out by the American Public Works Association with the assistance of the University of Florida, is referred to herein as the APWA report. One role of the APWA work was to provide an information base and methodology for estimating pollutant loadings and costs of wet weather pollution control. It was planned that the estimates provided by the report would be updated as additional information and improved methods became available. This report is the first step in updating the pollutant loading estimates in the APWA report.

The principal objective in updating the loading estimates has been to produce estimates of total loads to the Great Lakes from wet and dry weather municipal sources in Ontario. The following modifications have been made to the information and procedures in the APWA report:

1) Surface runoff and sanitary sewage loading estimates are based on concentrations representative of values recorded in Ontario communities.
2) The method for calculating combined sewage loadings has been changed.
3) Total annual loads have been estimated; the APWA report estimated only per-acre values.
4) An attempt has been made to compare loadings from the municipal sources with total loads to the Great Lakes from all Ontario sources.

An attempt has been made to assess the sensitivity of the estimated loadings to the most important assumptions on which the estimates depend.

PROJECT SUMMARY

Project Title	:	Workshop for Computer Modelling Technology Transfer, Canada-Ontario Agreement Storm Water Management Model SWMM Workshop, Conference No. 4
Scientific Liaison Officer:		J. Marsalek
Program Category	:	Implementation Strategy Development
Project Number	:	75-8-35
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 75/76: $18.0 K
Contractor	:	Proctor and Redfern Limited, and J.F. MacLaren Ltd.
Contract Time	:	November 1975 - March 1976
Status of Reports	:	Report on the workshop was issued as COA Conference Proceedings No. 4; see Appendix No. 1. Notes for Storm Water Management Model Workshop March 29-31, 1976 and October 19-21, 1976.

Description and Summary

The objective of the workshop was to familiarize potential users with the capabilities, limitations and general areas of use for modelling tools. The seminar was organized around the following guidelines:

1) State-of-the-art models currently in use were reviewed and current modelling status presented to decision-makers in urban drainage.
2) Lectures related to basic theoretical assumptions, state-of-the-art, validation by measurements, and limitations of STORM and SWMM models were presented assuring a basic working competence with the models.
3) Detailed computer programming sessions were included to acquaint participants with actual numerical examples.

There were two workshops staged by COA for Computer Modelling. The first one in March 1976 was arranged by Proctor and Redfern Ltd./J.F. MacLaren Ltd. The second workshop in October 1976 was arranged by the COA Urban Drainage Subcommittee.

PROJECT SUMMARY

Project Title	:	Planning Demonstration of SWMM at Meadowvale West Lake, Mississauga
Scientific Liaison Officer:		D. Weatherbe
Program Category	:	Solution Capability Development Implementation Strategy Development
Project Number	:	75-8-36
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 75/76: $4.7 K
Contractor	:	University of Toronto
Contract Time	:	November 1975 - February 1976
Status of Reports	:	Published as COA Research Report No. 63

Description and Summary

The study had the following objectives:

1) to obtain a calibrated simulation model for southern Ontario (SWMM and STORM),
2) to generate, with the above computer models, hydrographs and pollutographs for the Meadowvale development, both prior to and after development,
3) to assess behaviour of a detention pond under the supplied flow and loading rates using the modelling techniques.

Emphasis has been placed on building a flexible model to permit analysis of other sites, to determine efficiency of the siltation ponds, and to supply estimates of storm sewer pond effluent water quality. In addition, the recreational potential of detention ponds was evaluated in the context of water quality/quantity controls.

A thesis entitled "Storage as a Strategy for the Management of Storm Water from Residential Areas" (University of Toronto, 1975) was written by M.P.H. Murrey, as a result of the project.

Summary of Research Report No. 63

Project 75-8-36: STORAGE FOR STORM WATER QUALITY CONTROL - MEADOWVALE TEST SITE STUDY - M.P.H. Murrey and J.J. Ganczarczyk, University of Toronto

In the past five years there has been a proliferation of computer models for the simulation of urban runoff phenomena. The study described in the report has been based on two such models: the Storm Water Management Model (SWMM), developed for the U.S. Environmental Protection Agency by Metcalf and Eddy, Inc., the University of Florida, and Water Resources Engineers, Inc.; and the Storage Treatment Overflow Runoff Model (STORM), developed by Water Resources Engineers and currently managed by the U.S. Army Corps of Engineers. Both of these models have been used without any initial calibration. Therefore, the results presented are preliminary and must be verified by future measurements.

In this report, after presentation of general comments on the applied models, the development of a new subroutine is described. This is followed by the characterization of the test site and the results of the hydrological and pollution simulations. A new STORM subroutine program, MIKE, was developed to simulate the performance of an in-stream settling, basin-reservoir system for storm water quality control.

The objective of the study was to examine the behaviour of a settling basin-reservoir system used to control quantity and quality of storm water from residential areas. The computer models and proper data for the test site were used to generate prediction-of-flow hydrographs, pollutographs, and annual pollutant yields in a test catchment of the "new town" of Meadowvale prior to development and after its completion.

The proposed system at Meadowvale incorporates a 3700 m^2 (40 000 ft^2) siltation basin followed by a larger 4-ha (10-acre) reservoir. The catchment was simulated for before and after development conditions. Particular attention was paid to predicting pollutant yields, the quality of the reservoir water, and the operational efficiency of the siltation basin.

The following conclusions were drawn from the performed simulations of the Meadowvale test catchment:

1) Expected increases in annual pollutant yields (compared with the undeveloped conditions) were: BOD from 4.5 to 29.2 kg/ha (4 to 26 lb/acre); SS from 38.2 to 192 kg/ha (34 to 171 lb/acre); nitrogen from 1.1 to 11 kg/ha (1 to 10 lb/acre); and orthophosphate from 0.4 to 1.1 kg/ha (0.4 to 1 lb/acre). Hydrologically, peak flows may increase by a factor ranging from two to five depending on the storm frequency, while the total annual runoff would increase from 10.4 cm to 20.3 cm.
2) The silting basin with the dam to be constructed at Meadowvale should significantly improve runoff characteristics. Predicted yields of pollutants passing through the system to the Credit River were: BOD, 1.2 kg/ha (1.1 lb/acre); SS, 12 kg/ha (11 lb/acre); nitrogen, 7.9 kg/ha (7 lb/acre); and orthophosphate 0.7 kg/ha (0.6 lb/acre). It was estimated that the system as designed at Meadowvale would reduce peak flows to preurbanized levels or less for storms with return periods of less than one year.
3) For the design of storage systems in residential developments such as Meadowvale, consideration should be given to the use of two spillways; one to restrict flow and allow the use of available storage and the second to cater to large events (i.e., with a nominal return period greater than 25 years, for example). The increased costs of a higher dam and higher flood servitudes around the dam should not be significant at this scale of project, whereas the benefits of peak flow reduction are considerable.

The following recommendations were given:

1) The storm water quality control system, composed of a settling tank followed by a water reservoir, may be recommended as a relatively simple and reliable method for storm water pollution abatement in new residential developments.
2) Future monitoring of the Meadowvale test site is required to calibrate the models applied in this study and verify the accepted assumptions. Most sensitive parameters are: degree to

which surface is impervious, catchment width, infiltration capacity, surface depression, roughness and slope (listed in order of decreasing importance).

3) Many aspects of the suggested storm water control method are still not known well enough and require further research. Specific research requirements are:

   a) The settling behaviour of the storm water solids should be studied, with particular emphasis on the removals of nutrients and heavy metals obtainable under different hydraulic loadings.
   b) The reservoir quality simulation algorithms should be tested. It is probable that a more sophisticated approach (e.g., a biological model of the nutrient balance) may be necessary if acceptable results are to be obtained.
   c) The significance of snowmelt on reservoir water quality should be studied.
   d) The microbiological quality of the storm water runoff and the effects of prolonged storage on bacterial populations should be examined.

4) Based on predictions of pollutant concentrations in the reservoir, a seasonal algal growth can be expected.

5) The expected buildup of solids will be slow, chiefly due to the large area available for storage, and will average 1.3 mm/annum (0.05"/annum). Even during construction of the remaining undeveloped land, buildup of solids will be only moderate. The basin will trap floatables and has the potential to become anaerobic. A program for regular drawdown and cleaning should, therefore, be planned.

PROJECT SUMMARY

Project Title	:	Physical-Chemical Treatment and Disinfection of Storm Water
Project Leader	:	F.A. Tonelli
Program Category	:	Solution Capability Development
Project Number	:	76-8-37
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
76/77	17.1
77/78	10.7
Total	27.8

Contractor	:	Ministry of the Environment
Contract Time	:	April 1976 - March 1978
Status of Reports	:	Report will be published in 1980.

Description and Summary

A case-history study at the site of an engineered storage pond provided some insight into the aspects of the successful operation and management of such a pond. An engineered storm water retention basin was monitored for 12 months with respect to the following:

1) hydraulic loading and detention vs sedimentation efficiency,
2) build-up, content, and effective management of sediment removal,
3) incoming and outgoing bacterial levels,
4) normal wastewater parameters such as BOD and TSS.

Bench-scale treatability studies for phosphorus, suspended solids, and total and fecal coliforms, and jar tests for coagulation addition, and chemical demand tests for disinfection by chlorine were also carried out.

PROJECT SUMMARY

Project Title	:	Manual of Practice on Urban Drainage
Scientific Liaison Officer	:	D.G. Weatherbe
Program Category	:	Implementation Strategy Agreement
Project Number	:	76-8-38
Funding Source	:	100% Canada-Ontario Agreement

Funding :

FY	$ K
76/77	5.6
77/78	3.0
Total	8.6

Contractor	:	Environment Canada, Ontario Ministry of the Environment
Contract Time	:	April 1976 - March 1979
Status of Reports	:	Draft No. 3 was released with a limited distribution of several hundred copies in March 1977 at the Conference of Modern Concepts for Urban Drainage. Draft No. 4 will be published as a COA Report in 1980.

Description and Summary

The objective of this project was to compile a manual outlining the practice and ramifications of urban drainage control concepts that would be of value to municipalities, town planners, contractors, consultants and government agencies. A manual outlining procedures for implementation of runoff controls in new urban developments has been developed. The manual covers the following topics:

1) policy objectives,
2) analysis and design techniques for storage ponds used for retarding runoff rates and sedimentation,
3) rainfall analysis/design storm definitions,
4) computer model use,
5) inlet controls,
6) quality control options, and
7) municipal bylaws.

PROJECT SUMMARY

Project Title	:	Systems Demonstration of Storm Water Management Technology at St. Thomas, Ontario
Scientific Liaison Officer:		D.G. Weatherbe
Program Category	:	Implementation Strategy Development
Project Number	:	76-8-39
Funding Source	:	Canada Mortgage and Housing Corporation, CMHC-SCAT Funds were used for cost sharing with the municipality.
Funding	:	No financial support to this project from the Canada-Ontario Agreement
Contractor	:	J.F. MacLaren Ltd.
Contract Time	:	April 1976 - March 1977
Status of Reports	:	Report issued by Canada Mortgage and Housing Corporation

Description and Summary

The objective of the study was to apply advanced storm water management technology in a municipality (St. Thomas) with urban drainage problems such as local flooding, combined sewage overflows, or sewage treatment plant bypasses. Storm water management models (STORM and SWMM) were used for the following:

1) to assess the magnitude and frequency of storm waste loads to the receiving stream,
2) to estimate the efficiencies of wet weather (vs dry weather) treatment in meeting environmental quality objectives,
3) to estimate the storage or treatment capacity required to achieve a given level of pollution control of wet weather discharge,
4) to design system changes required to reduce local flooding,
5) to calculate costs of achieving a given control level,
6) to indicate the most cost effective combination of options to achieve environmental and flood control objectives.

PROJECT SUMMARY

Project Title	:	Canadian Municipal Practices Review
Scientific Liaison Officer:		D.J. Hay
Program Category	:	Implementation Strategy Development
Project Number	:	76-8-40
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 76/77: $8.0 K
Contractor	:	Gore and Storrie Ltd.
Contract Time	:	April 1976 - March 1977
Status of Reports	:	Published as COA Research Report No. 82

Description and Summary

This project was carried out in Canada along similar lines to the Foreign Practices Regulatory Review conducted by Albery, Pullerits, Dickson and Associates on Project 74-8-17. The objective of the program was to investigate, across Canada, pollution problems associated with storm sewer discharges and combined sewer overflows. Consideration was given to statutory policies governing storm discharges and overflows, and present design practices covering methods of problem identification were studied. This project was conducted in parts of Canada outside Ontario, and is similar to project 74-8-10.

Summary of Research Report No. 82

Project 76-8-40: REVIEW OF CANADIAN MUNICIPAL URBAN DRAINAGE POLICIES AND PRACTICES - Gore and Storrie Limited, Toronto, Ontario

As a part of the research and development program of the Urban Drainage Subcommittee of the Canada-Ontario Agreement on Great Lakes Water Quality, a study of the current policies and practices across Canada with respect to urban storm water drainage was made. The information was assembled from a questionnaire sent to their regional

offices by the Environmental Protection Service of Environment Canada. Three categories of major urban drainage practices were included in the questionnaire:

1) design of new sewer systems,
2) abatement of pollution due to combined sewer overflows, and
3) field studies of sewer systems.

There did not appear to be any great variations among the policies and practices used for urban drainage in the various provinces across Canada. There were, however, minor variations in approach due to local conditions. At the present time, it appears that we are in a transition period in which new ideas on urban drainage and storm water management are being adopted; change is occurring more rapidly in some provinces than in others, partly due to geographical location and partly to considerations of economic growth.

Nevertheless, all provincial regulatory bodies are generally becoming more aware of the problems of urban drainage and are concerned with the quality effects on receiving waters. Ontario, for example, has taken a definite step towards storm water treatment by requiring quality control of urban surface runoff into the Rideau River in the Ottawa area.

At the municipal level, there was concern in many of the larger and older cities and towns in Canada with both quality and quantity problems of urban drainage particularly where these problems arise from combined sewer overflows. Authorities in Vancouver and Toronto have engaged consultants to analyze their problems. New methods and techniques for management of all aspects of urban drainage runoff, including analysis by one or more of the mathematical simulation models that are now available for this purpose, were being examined in many municipalities.

The Urban Drainage Program of the Urban Drainage Subcommittee has three main objectives:

1) the identification of urban drainage problems,
2) the development of a capability to solve these problems, and
3) the development of a strategy to implement solutions.

About 40 research projects have been undertaken by the Subcommittee and considerable progress has been made with respect to the first two of the above objectives. Work is now proceeding with respect to the third objective. At an Urban Drainage Conference held in Toronto, Ontario, March 1977, the Subcommittee presented a draft of a "Manual of Practice on Urban Drainage" for review and comment by persons interested and working in this field. It sets out current thinking and new practices in urban drainage in the form of a useful reference document.

In addition, certain research projects have been sponsored by Canada Mortgage and Housing Corporation. An intensive study has been undertaken by the City of Winnipeg, Manitoba to examine all aspects of storm water impoundments constructed in that city. A systems-demonstration study of storm water management technology carried out in St. Thomas, Ontario relates to urban drainage problems of local flooding, combined sewage overflows, and sewage treatment plant by-passes.

These projects have not only provided additional knowledge on the subject of urban drainage as it applies to Canadian conditions, but have given considerable impetus to the application of storm water management techniques all across Canada.

The Canada-U.S. Agreement has enabled the establishment of a close association with the United States Environment Protection Agency. Considerable benefit has been obtained from the work done by that agency in providing a background for our own development work in this field.

Attention is increasingly being given to methods of solving quantity and quality problems through the provision of upstream or downstream storage controls for combined sewer overflows and inflow and infiltration. The control of pollution from street runoff and snow removal and disposal is becoming a vital part of urban watershed management. The requirements and methods for storm water treatment are now being considered. In the past it was not possible to correlate all of these factors, but with the assistance of the computer and the use of mathematical models this is now becoming feasible. There is still much work to be done, however, in collecting background data and refining and calibrating some of the technical aspects of the computer programs in order to obtain the closest relationships to actual conditions.

In Canada as in other countries, the main emphasis of pollution control has until recently been on sanitary and industrial wastes. More attention is now being given to the problems of urban drainage. Although there is no indication that Canada is behind other countries in this area, continued leadership, encouragement and support from the governments involved are necessary for the achievement of success.

PROJECT SUMMARY

Project Title	:	Integration of Reports on Projects 73-3-12+, 74-8-4 and 75-8-34 into one final report.
Scientific Liaison Officer	:	J. Marsalek
Program Category	:	Solution Capability Development and Problem Definition
Project Number	:	77-8-43
Funding Source	:	100% Environment Canada (EPS)
Funding	:	FY 77/78: $1.0 K
Contractor	:	James F. MacLaren Ltd.
Contract Time	:	May 1977 - January 1978
Status of Reports	:	Published as a COA Research Report No. 100

Description and Summary

Reports on Projects 73-3-12+, 74-8-4, and 75-8-34 were originally written as three separate reports scheduled to be published as Volumes I, II, and III. These three volumes have been compiled into one report by James F. MacLaren Ltd.

Summary of Research Report No. 100

Project 77-8-43: BRUCEWOOD URBAN TEST CATCHMENT - James F. MacLaren Ltd.

The purpose of this study was to examine a typical modern subdivision and evaluate the feasibility of using a computer model to predict the quantity and quality of stormwater runoff from the subdivision due to rain storms and melting snow.

The Brucewood subdivision in North York, Toronto was selected as a typical modern subdivision. It is a 48-acre development consisting of single-family and semi-detached residences built in the late 1960's. During the period February 15, 1974 to December 31, 1975 the quantity and quality of storm water flows were monitored, and other field data (e.g.,

rainfall, temperature, street cleaning frequency, and so on) were gathered. The collected data were used to calibrate and verify the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM).

Several events were simulated using the model (SWMM). Quantity simulations compared reasonably well with recorded flows in general and with medium and higher intensity rainfalls in particular. Quality simulations were not as accurate as flow simulations. This was attributed to the more complex phenomena involved in quality simulation. In general, the simulated pollutant concentrations were of the same order of magnitude as those recorded.

The pollutant concentrations measured in the runoff from the Brucewood subdivision were comparable to those typically obtained from secondary effluents of municipal treatment plants. Peak suspended solids concentrations, in particular, were similar to those typically found in untreated domestic sewage.

For some pollutants, the ranges of concentrations measured in rainfall samples were of the same order of magnitude as those measured in the surface runoff. It was concluded that in certain meteorological conditions, the washout of pollutants from the atmosphere can be a significant source of pollution.

The default values programmed in the SWMM are considered suitable for most runoff quantity simulation purposes when local data are unavailable. Further measurement programs directed solely at the verification of the SWMM quantity routines are not required (with the exception of snowmelt quantity).

SWMM flow simulation was noticeably more accurate than SWMM simulation of storm water quality. Even with a calibrated model, measured pollutant concentrations can generally only be reproduced to within an order of magnitude.

APPENDICES

APPENDIX 1: STORM WATER MANAGEMENT MODEL WORKSHOPS, Conference Proceedings No. 4 (COA Project 75-8-35), held in Toronto, Ontario, March 29, 30 and 31, 1976, and October 19, 20, and 21, 1976.

The two Canadian Storm Water Management Model Workshops dealt with urban storm water management and in particular with the storm water management model described in project 73-5-10. Under provisions of the Canada-Ontario Agreement, the firms of Proctor and Redfern Limited, James F. MacLaren Limited, and Dorsch Consult Limited were commissioned to modify and further develop the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) (see Canada-Ontario Agreement Research Reports No. 47, 48 and 62). These modifications were related particularly to Canadian conditions. For example, one of the largest additions to the model was a new snowmelt routine, which is also being implemented in the official U.S. version. Additional work has been conducted on other blocks of the model; for example, a study of simplified simulation using SWMM was carried out. New routines for managing and analyzing the large quantities of meteorological data have been written and are included in the presentations.

The SWMM version which resulted from this joint study was the subject of this workshop. The first goal was to provide some background to the technology of urban storm water modelling. This is a rapidly changing field and, to properly use the model, an appreciation of the overall state-of-the-art is necessary. Second, it was intended to provide those attending the workshops with enough information to begin modelling on their own. Instruction was given on how to set up and conduct a simulation for a specific problem area using the Canadian SWMM. The workshop was also intended to initiate interest in the use of SWMM in Canada, even among those who will not be directly involved in running the model. There are numerous potential applications of the SWMM and related models in Ontario today. Large numbers of combined and separate sewer systems are in existence and they discharge overflows to receiving water bodies. As the systems become larger and more complex, the use of the computer models to standardize and facilitate the analysis and computation of flows in these systems will become more and more necessary. Computer

models such as SWMM represent an attempt not to replace but to support engineering judgement.

The latest refinements of the SWMM model, which were developed recently by the University of Florida under the sponsorship of U.S. EPA, were also presented at the workshops.

The sessions consisted of both lectures and workshops to gain practical modelling experience. In the lectures, background material and theory behind the models and their computations, as well as instructions in their use, were presented. In the workshops, some practical problems were posed, input data were prepared, and simulation results were distributed and discussed.

COA CONFERENCE PROCEEDINGS NO. 4

Papers included:

Papers included (cont'd):

APPENDIX 2: MODERN CONCEPTS IN URBAN DRAINAGE, Conference Proceedings No. 5, Toronto, Ontario, March 28-30, 1977.

The Government of Canada and the Government of Ontario in 1971 started a cooperative program to ensure that the water quality of the Great Lakes is restored and protected. One aspect of the program was the funding for investigative work to define urban drainage problems and develop techniques and solutions to the problems. In this endeavour, assistance was provided by funding from the Canada/United States Agreement on Great Lakes Water Quality and from Canada Mortgage and Housing Corporation.

A conference entitled "Modern Concepts for Urban Drainage" was arranged on March 28-30, 1977, in Toronto, Ontario, to culminate and report four years of research and development in this field by the Federal and Ontario Governments. The area covered by the conference included all aspects of urban drainage from its pollution and hydrological impact to the new methodology and criteria for its control.

The papers presented at the conference provided an overview of the Canada-Ontario Urban Drainage Program, information on pollution sources and their effects, discussions of the application of computer models for analyzing urban drainage problems, and a review of existing practices and policies. The conference was designed to cover in a practical and economical way many of the questions concerning urban drainage and to be of interest to those involved in both the administrative and technical aspects of urban runoff.

The attendance at the conference was about 400, and included municipal engineers, elected officials, consultants, planners, and the staff of regulatory agencies involved with urban runoff. The employers of those in attendance are summarized below.

Federal Government	7%
Provincial Government	18%
Municipal Government	15%
Consulting Engineers	52%
Other	8%

A highlight of the conference was the distribution of about 600 copies of the "Manual of Practice on Urban Drainage, Draft No. 3". It was the plan of the Urban Drainage Subcommittee to produce this manual, which contains information obtained from research projects costing approximately 1.5 million dollars conducted between 1972 and 1977. The first draft was compiled in December 1976 and improved into Draft No. 2, which was printed in February 1977. Draft No. 3 was issued for review and discussion at the Urban Drainage Conference in March 1977.

On March 30, 1977, Draft No. 3 of the manual was introduced and described in a paper at the conference and one afternoon session was alloted to a panel discussion. Suggestions and ideas from the conference and especially from the panel discussion assisted in improving the document. Draft No. 4 will be issued in the Canada-Ontario Agreement Publications Series.

It is hoped that the manual, when completed, will be of value to municipalities, town planners, contractors, consultants, and government agencies. The manual should not be considered to represent a statement of the Ontario Government on policy or guidelines on the subject of urban drainage. It is a technical document reporting the findings and observations of the Urban Drainage Subcommittee from their recent investigations concerning the problems of urban drainage.

The manual has been developed by the cooperative effort of the Urban Drainage Manual Working Committee with membership from Municipal, Provincial and Federal Governments as follows:

J.J. Armstrong	Ministry of Transportation and Communications
D.B. Cane	Ministry of the Environment
R.E. Crawford	Municipal Engineers Association of Ontario
L.A. Drennan	Environment Canada
T. Kurtz	Ministry of Natural Resources
S. Llewellyn	Environment Canada
G.O. MacLellan	Ministry of Housing
R.A. Madill	Ministry of Transportation and Communications
J. Marsalek	Environment Canada
F.S. Martin	Ministry of Housing
Z.D. Novak	Ministry of the Environment
D. Persaud	Ministry of the Environment
G. Sardesai	Ministry of Natural Resources
P. Seto	Ministry of the Environment (Co-Chairman)
E.R. Simonen	Municipal Engineers Association of Ontario

F.A. Tonelli	Ministry of the Environment
H.C. Torno	United States Environmental Protection Agency
D.H. Waller	Nova Scotia Technical College
D.B. Walter	Environment Canada
B.R. Ward	Ministry of the Environment
D.G. Weatherbe	Ministry of the Environment (Co-Chairman)

Six chapters in the manual were compiled under the supervision of the following principal chapter writers:

Chapter Number	Principal Chapter Writer
1	D.H. Waller
2	D.G. Weatherbe
3	J. Marsalek
4	F.A. Tonelli
5	F.A. Tonelli
6	B.R. Ward

It is re-emphasized that the manual is the result of the efforts of the Working Committee and does not necessarily constitute the policies of the government agencies they represent.

Numerous projects have been carried out for the Urban Drainage Subcommittee by external contractors and government researchers many of whom are referred to in the manual. The manual committee would like to thank the many agencies, consultants, and individuals who provided input material to the manual. The efforts of James F. MacLaren Ltd. and Paul Theil Associates Ltd. who provided under contract, planning and design examples for the manual are acknowledged.

COA CONFERENCE PROCEEDINGS NO. 5

Papers included:

COA CONFERENCE PROCEEDINGS NO. 5

Papers included (cont'd):

HYDROLOGICAL ASPECTS OF URBAN DRAINAGE
Ivan F. Lorant, Water Resources Engineering, M.M. Dillon Limited

POLITICAL ASPECTS OF URBAN DRAINAGE
L.D. House, City of St. Thomas, Ontario

A REVIEW OF URBAN RUNOFF MODELS
Alan R. Perks, Proctor and Redfern Limited

DATA COLLECTION, INSTRUMENTATION AND VERIFICATION OF MODELS
J. Marsalek, Canada Centre for Inland Waters, Environment Canada

APPLICATION OF COMPUTER MODELS FOR STORM WATER MANAGEMENT
Paul E. Wisner, James F. Maclaren Ltd.

TREATMENT TECHNOLOGY FOR URBAN RUNOFF
F.A. Tonelli, Pollution Control Branch, Ontario Ministry of Environment

A SYSTEMS DEMONSTRATION IN THE CITY OF ST. THOMAS
W.E. Clarke and R.W. Kuzyk, James F. MacLaren Limited

URBAN DRAINAGE DESIGN FOR NEW DEVELOPMENT
Paul E. Theil, Paul Theil Associates Limited

URBAN DRAINAGE PRACTICES IN CANADA
K.W. Moore, Gore and Storrie Limited

EROSION CONTROL METHODS DURING CONSTRUCTION
J.J. Armstrong, Ministry of Transportation and Communications

INTRODUCTION TO THE "MANUAL OF PRACTICE ON URBAN DRAINAGE"
P. Seto, Pollution Control Branch, Ontario Ministry of Environment.

APPENDIX 3: PROPOSED MODEL POLICIES FOR URBAN DRAINAGE MANAGEMENT, COA Project 77-1-47

A substantial number of research studies have been carried out by the Urban Drainage Subcommittee to determine the magnitude of pollution from urban drainage sources and to develop analytical and control techniques pertaining to these pollution sources. These studies indicated a cause for concern because urban runoff, and particularly combined sewer overflows, have been found to be major sources of pollutant loadings to receiving waters. The studies also indicated that technology was available to aid in abating pollution from these sources. It became clear that pollution from urban drainage could not be controlled without considering flooding problems as well. Consequently, the Urban Drainage Subcommittee requested that an Urban Drainage Policy Committee be formed to consolidate all the research and development findings generated by the Canada-Ontario Agreement and elsewhere and to propose comprehensive model policies for urban drainage management which would lead to the alleviation of pollution as well as the resolution of flooding problems in urban areas. It was also requested that the proposed model policies take account of the administrative and legislative framework in Ontario. In this way, the model policies could then be considered for adoption by the Ontario Government. With minor but appropriate modifications, these model policies could also form the basis of urban drainage management programs for other jurisdictions.

With the submission of the Proposed Model Policies for Urban Drainage Management as the final report of the Urban Drainage Policy Committee, it must be stressed that this Committee was not specifically charged with developing official policies for Ontario. This must await the formation of an Ontario Policy Implementation Committee and an evaluation of the impact which the proposed model policies would have on the financial and human resources in Ontario if adopted by the Province. Nevertheless, the Policy Committee feels that the concepts outlined in its report, if incorporated into concrete policies, could prove both economic to implement and beneficial to the people of Ontario.

The Policy Committee consisted of the following:

R. Crawford	Municipal Engineers Association of Ontario
T.C. Clarke	Environment Canada
D. Hay	Environment Canada
L. Kamp	Environment Canada
T. Kurtz	Ministry of Natural Resources
F.I. Lorant	M.M. Dillon Limited (consultant under contract)
G.O. MacLellan	Ministry of Housing
J.R. McMurray	Ministry of Environment
R.A. Madill	Ministry of Transportation and Communications
J. Marsalek	Environment Canada
F.S. Martin	Ministry of Housing
D. Persaud	Ministry of Environment
T. Simonen	Municipal Engineers Association of Ontario
G.S. Sardesai	Ministry of Natural Resources
P. Seto	Ministry of Environment
J. Shimwell	Canada Mortgage and Housing Corporation
L. South	Ministry of Environment
F.A. Tonelli	Ministry of Environment
H. Torno	United States Environmental Protection Agency (Advisor)
D. Veal	Ministry of Environment
D. Waller	Nova Scotia Technical College (Advisor)
B.R. Ward	Ministry of Environment
D.G. Weatherbe	Ministry of Environment

SUMMARY OF PROJECT 77-1-47

The Urban Drainage Policy Committee was formed in 1977 to propose model policies for control of flooding, pollution and erosion problems resulting from urban drainage. On the basis of studies carried out by the Urban Drainage Subcommittee of the Canada-Ontario Agreement on Great Lakes Water Quality, it was generally recognized that combined sewer discharges and storm drainage from urban areas represented a significant source of pollutants. The development of urban areas results in potentially increased erosion of land, turbidity and sedimentation in watercourses during and after the construction periods. Urban areas, by their nature, create large impervious surfaces which result in increased volumes and rates of runoff. The construction of storm drainage systems, which are traditionally designed to remove the runoff as quickly as possible, will accelerate flooding, erosion, and sedimentation in downstream natural watercourses. Improper sewage system layout or design may cause frequent combined sewer overflows and treatment plant by-passes. Inadequate sewer facilities, coupled with inappropriate drainage designs, may cause on-site

flooding and structural damage. Lack of coordination among government agencies concerned with drainage matters may, at times, result in incompatible drainage policies and guidelines, and lengthen the administrative and approval procedures.

The above mentioned variety of drainage-related problems have been experienced to a certain extent in some of Ontario's developed or developing urban areas mainly because most of the traditional approaches to urban drainage management are still being used. Continuation of the present approaches will intensify these drainage problems, with costly remedial measures to follow.

The assessment of current practices in urban drainage planning and engineering demonstrates the need for a new and more comprehensive approach. The new approach requires the application of new drainage concepts through a broader use of existing municipal planning mechanisms, using new and innovative technology where needed. The approach is delineated in the following five policy proposals:

1) Municipalities, in coordination with the conservation authorities, will be required to develop master drainage plans for all watersheds in their boundaries. The purpose of this policy is to foster master drainage planning for rapidly developing municipalities to ensure that storm water drainage systems are developed in a manner compatible with watershed needs, to identify existing water quality and flooding problems, and to avoid future problems.
2) Municipalities with sewage collection and treatment systems will be required to formulate and implement a comprehensive pollution control strategy which includes consideration of both wet and dry weather pollution sources. In the initial stage of the formulation, an in-system review of the relatively unknown wet weather sources, volumes, and magnitudes of pollution would be required as a basis for plan formulation. Consideration of receiving water objectives and the cost and effectiveness of wet weather versus dry weather controls would lead to a final comprehensive strategy. The end result will be more cost-effective investment in municipal pollution control.

3) New drainage systems for all development will be required to be designed using the major-minor concept which recognizes the dual role of the drainage system in providing convenience during minor (high frequency) runoff events and minimizing property damage and protecting life during major (rare) runoff events. Expenditures for sewer construction are expected to be reduced since the minor system would be designed to avoid excessive costs through the use of overly conservative design techniques or excessively rare design storms, bearing in mind that the major system would be designed to provide protection against damage from storms which exceed the capacity of the minor system. The overall drainage system would provide a higher level of protection because the major system of flow routes on roadways and drainage easements would be designed for rare events. It would also be recognized that some level of inconvenience would be experienced from time to time.

4) Proponents of new urban developments will be required to assess the effects of the development on the watershed and to carry out mitigating measures as required. Hydrologic changes and pollution effects on the receiving watercourse are considered to be the important effects in this case.

5) Proponents of new urban developments will be required to plan for and carry out an erosion and sediment control program, in the planning and construction stages of development, and to follow it up with an adequate maintenance program. It is felt that construction-generated sediment pollution is a severe enough problem to justify controls on an across-the-board basis.

The acceptance and implementation of these policy proposals will ensure that past drainage problems are minimized and needless expenditures avoided. It will also provide for improved safety and enhancement of the environment, in most cases without increasing the total cost of the urban drainage system and, in some cases, lowering the cost. Furthermore, through the implementation of these proposed policies, the various government agencies involved will be better coordinated and the

present urban drainage administrative and approval procedures will be stream-lined.

Adequate planning procedures are currently available in Ontario for the adoption and implementation of these model policies, and the legislation is in place to support the policies. In addition, packages of computer models which can be used for the analysis of urban runoff systems and for comparing various drainage, storage, and treatment alternatives are available. Various strategies for controlling runoff quantity and quality have been demonstrated on a pilot or full-scale basis. It is apparent that technologies are in place to facilitate use of the model policies. In fact, certain municipalities in Ontario are already using these analytical and control technologies to resolve drainage and pollution problems.